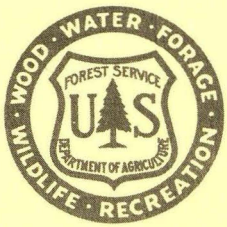
REPORT
1964



Northeastern Forest

Experiment Station

REPORT 1964

Northeastern Forest Experiment Station

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FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE • UPPER DARBY, PA.
NORTHEASTERN FOREST EXPERIMENT STATION • • 1965
Ralph W. Marquis, Director

IN GENERAL

IN SPITE of several setbacks, this has been another year of progress for the Northeastern Forest Experiment Station. First, the setbacks: We have become accustomed to a certain amount of turnover in scientific personnel. Each departure of a trained researcher leaves a void, but as the size of our staff increases, replacements are made more easily; and we have a group of young scientists anxious and ready for advancement. Ashbel Hough (silviculture, Allegheny hardwoods) and Jesse Diller (pathology) retired, but both have been back for part-time service. John Phillips and Gray Bolich resigned for personal reasons. Two men accepted university posts: Frank Santamour (genetics), who went to the University of Pennsylvania, and Arthur Eschner (watershed), who went to the New York State College of Forestry. Three men moved to other positions in the Forest Service: Hubert Burke (recreation) to the Rocky Mountain Station, Robert Brandt (diseases) to the Washington Office, and Gary Lindell (marketing) to the Lake States Station.

Setback number two was the loss by fire of the New Haven insect and disease laboratory. Setback number three, as unexpected as the New Haven fire, was the instruction to close out the coastal oak-pine silviculture and cooperative watershed projects at New Lisbon, N. J., by July 1. We are now planning ways to take care of the personnel involved and to continue the most important studies from other project locations.

We have made notable progress in upgrading our field office and laboratory facilities. Staff is now occupying new quarters at Parsons, W. Va., and Warren, Pa. Leases have been negotiated for sites at Morgantown, W. Va., and Burlington, Vt.; and sites have been purchased at Hamden, Conn., and Radnor, Pa. Office-laboratory construction plans are being prepared for a new insect-disease laboratory at Hamden, a forestry sciences laboratory at Morgantown, and an office-laboratory building for Region 7 and Station headquarters in Radnor.

Appropriation increases have given support to going programs and impetus to new programs. Silviculture and watershed-management research at Parsons, W. Va.; maple research at Burlington, Vt., and insect research at New Haven were strengthened. A new project in forest engineering research at Morgantown got a modest start.

With these increases, the overall program of the Station is attaining a better balance, though still not a perfect one. Wildlife-habitat, engineering, watershed-management, recreation, disease, and utilization research need further support to catch up with our other and better established programs and to provide a more complete coverage of the forestry problems of the Northeast.

These are just rambling highlights. For a more substantive review of recent research accomplishments, read on.

TIMBER MANAGEMENT

THIS year we shall report progress by projects instead of by a few major subject matter areas as has been done in the past. Each of the 10 projects within the Division of Timber Management has an average of 18 studies. But only those studies that yielded significant results or progress during 1964 are reported here. However, before describing the project accomplishments, a few special notes of progress should be mentioned:

1. A cooperative study of the seed production of seven hardwood species was begun on the Allegheny Plateau. Our cooperators include several wood-using industries and State and Federal agencies.
2. A cooperative tree-improvement program on black cherry was launched in 1964 by the Station and the Allegheny National Forest. This program includes selecting superior cherry trees and developing seed orchards from these trees.
3. The Station was a co-sponsor of a direct-seeding symposium with the University of Massachusetts, the University of Maine, and the Maine Forest Service at Amherst, Mass., in August.
4. The Divisions of Timber and Watershed Managament Research held a 2-day technical meeting at Blackwater Falls, W. Va., in late August. Foresters from universities in the area, from industry, from the Extension Service, and from other State and Federal agencies of the Appalachian Region attended the meeting.
5. In September the Station and the Pennsylvania State University cosponsored an international meeting — the Advanced Study Institute on Genetic Improvement for Disease and Insect Resistance of Forest Trees. The meeting was held at University Park, Pa.
6. For purposes of economy and efficiency, the 2-man staff at the Williamstown, Mass., unit was removed and the responsibilities for continuing current studies there have been assigned to the genetics project at Durham, N. H.
7. A cooperative tree-improvement program on pitch and loblolly pines and pitch-loblolly hybrids for the Northeast was begun in 1964 by the Station (New Lisbon project) and the West Virginia Pulp and Paper Company. Much assistance was given by State and other Federal and private organizations.

MAPLE SUGAR PRODUCTION

Burlington, Vt.

In 1957 two new projects were begun at Burlington, one on the improvement of sugar maple for sugar production and the other on the planting and seeding of northern hardwoods. Both projects were admirably suited to the location because of the research programs already in existence at the University of Vermont and the general interest evident in these projects. Excellent cooperation and working relationships between the University's forestry and botany departments and Northeastern Station have continued to grow over the years.

In 1964 a new appropriation ($90,000) was voted for the Station by Congress to expand the maple sugar project into new areas of sugar bush management, tapping, collection, and associated and supporting studies in the physiology of sap flow and translocation. In voting the appropriation, Congress also expressed its approval for the establishment of a national sugar maple laboratory, as a part of the Northeastern Station, at the University of Vermont.

Improvement of Sugar Maple

Cooperative surveys to select phenotypes for high sugar production continued in 1964. The survey was expanded to help determine where future intensive selection work should be concentrated, if it is found that between-tree variability in sap sugar content is greater in some areas.

A total of 152 trees were found in 1964 that met the initial minimum screening criteria of exceeding the surrounding "standard" trees by at least 30% in average sap sugar content.

Unusually high selection differentials were observed. Among the 152 trees selected for further screening, 46 trees exceeded the standard average by at least 50%, and 6 of these trees tested between 90 and 100% above the average.

The following tabulation summarizes in part the results of the 1964 survey conducted primarily by State foresters, extension foresters, and county agents:

State	*Sugar bushes surveyed (No.)*	*Trees tested (No.)*	*Selected phenotypes (No.)*
Maine	4	400	3
Massachusetts	36	2,436	37
New Hampshire	8	417	10
New York	11	659	9
Vermont	33	4,341	93
Total	92	8,253	152

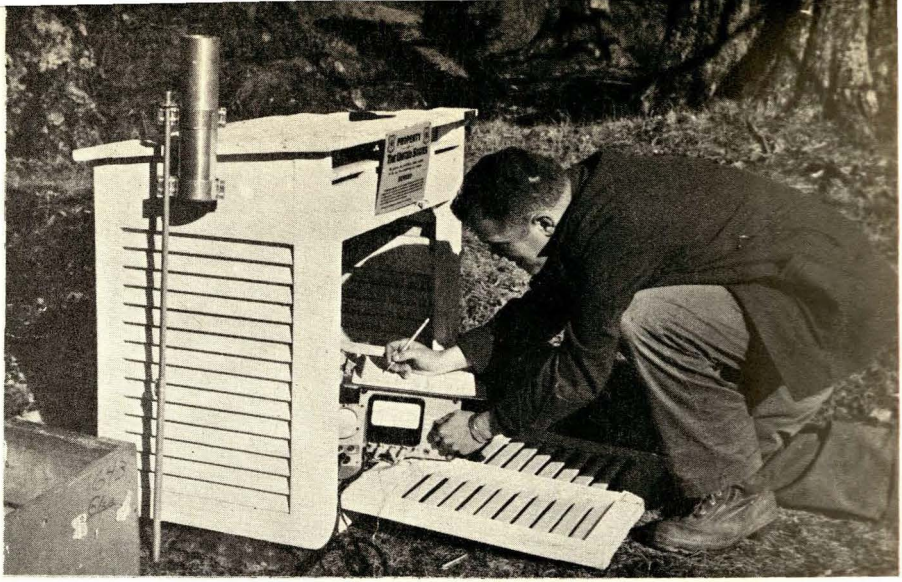
Individual tree-seed collections received from 32 sources throughout the range of sugar maple will form the basis for studying genetic variability within and between provenances. Enough seed has been received by the Northeastern Station to install six outplantings. Outplantings are being planned at Burlington, Vt.; Orono, Me.; and Parsons, W. Va. Cooperators are planning two more outplantings at the Michigan College of Mining and Technology, Houghton, Mich., and one at Laval University in Quebec City.

Maple Propagation

Successful methods of vegetative propagation from cuttings — and the establishment of these cuttings when nursery or field-planted—are important to the continued progress of the sugar maple improvement research program. Present emphasis is on increasing the overwintering survival of rooted greenwood cuttings. Approximately 1,200 rooted cuttings, representing a rooting success of 42%, were obtained from an early summer rooting program. These cuttings are being overwintered under two treatments involving four different storage conditions. The storage conditions include direct nursery outplanting, cold-frame storage, and refrigerated storage at two levels. It is hoped that the average survival rate of 9%, as obtained from previous overwintering attempts, may be increased.

Maple Sap Production

Research in the production of maple sugar sap began last fall at Burlington with an investigation of the feasibility of off-season tapping. The effects of fall tapping on the volume and sugar concentrations of trees that are tapped both in the fall and spring are of major interest. Another important variable in the current study is that of aspect and its influence on sap volume and sugar concentration. Temperature and moisture relationships of the environment are also being observed.



Soil moisture and temperature values being recorded in an experiment to test the feasibility of off-season tapping of sugar maples. The instrument attached to the side of the shelter is a rain gage.

PLANTING AND SEEDING HARDWOODS

Burlington, Vt.

In the planting and seeding project, first priority among northern hardwood species has been assigned to sugar maple to complement the work being done on maple sugar production at Burlington.

An important area of research on planting and seeding sugar maple is in the handling and storing of seed to prevent loss of viability, which often becomes critical during years of insufficient seed crops. Significant progress has been made in finding how both seed moisture content and storage temperature control viability of sugar maple seeds after two winters of storage (table 1).

In a search for the best germination media for testing viability of sugar maple seed, equally good results (over 96.8 percent germination) were obtained from sand, perlite, sphagnum moss, and germination paper. And the results of a fall-versus-spring sowing study in the nursery favored fall sowing. However, before final recommendations can be made, the length of the stratification period and soil moisture relationships of the seedbeds during the spring germination period will need further investigation.

The objective of another nursery study was to produce seedlings with compact fibrous root systems that would simplify outplanting operations and increase the chances for seeding survival and fast, early growth. Lateral root pruning on first-year seedlings showed that many new roots are formed at the point of severance of the initial lateral roots. Pruning also appeared to increase the fibrous root mass behind the pruned portions. Although the results are not conclusive, pruning may be an important forward step in the production of superior planting stock.

A start on delimiting optimum conditions for the field establishment of sugar maple was made last fall on the Green Mountain National Forest. One study is designed to test site-preparation treatments and protection from

Table 1. — *Viability of sugar maple seeds after two winters of storage under varying temperature conditions and moisture content, in percent*

Seed moisture content (percent)	Storage temperature and duration							
	+65°F.		+45°F.		+35°F.		+15°F.	
	5 months	17 months	5 months	17 months	5 months	17 months	5 months	17 months
35	0.0	0.0	89.6	0.0	94.6	10.2	94.7	93.0
25	16.1	.0	97.0	62.6	97.3	91.4	94.8	97.3
17	40.6	.0	97.2	70.7	98.5	95.0	97.9	97.7
10	94.8	72.5	94.1	95.2	96.7	96.0	96.7	96.2

wildlife damage with 2-0 seedlings. Another approach is a study of direct seeding versus planting on an old field.

Two environmental aspects of importance to survival and seedling development, both in nursery and field, are moisture and nutrient level. Midseason results of a cooperative study with the Forestry Department of the University of Vermont indicated a greater height and diameter-growth response to moisture at low nutrient levels compared to a high level of nutrition. Other parameters being examined are apparent photosynthesis, sugar and starch content of roots and stems, and plant weights.

BEECH-BIRCH-MAPLE

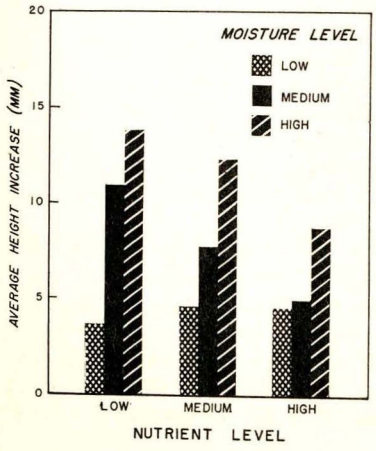
Laconia, N. H.

The timber-management project at Laconia is concerned with investigations of the silvics, silviculture, and management of the important hardwood species in the beech-birch-maple or northern hardwood type of New England. During the past year, personnel at this project acquired new fundamental information on the nutrition and regeneration of yellow and paper birch.

Nutrient Uptake by Yellow Birch

Yellow birch foliage samples were collected throughout the 1962 growing season from 80-year-old trees, 60 to 70 feet tall, growing on both well-drained and poorly drained podzol soils. The study areas were located on

Average height increase of sugar maple seedlings at midseason as affected by varying the nutrient and moisture levels of the rooting medium.



the Bartlett Experimental Forest in New Hampshire.

Foliar nutrient analyses disclosed three distinct seasonal patterns. The first included nitrogen, phosphorus, potassium, and sulfur. In general, the amounts of these four elements increased rapidly during spring leaf expansion, fluctuated slightly during summer, and then decreased sharply during late September before leaf abscission in October. Calcium contents, which showed a second pattern, continually increased throughout the entire season. Magnesium, which displayed a third pattern, increased to peak levels by late July or early August and then quickly decreased during the remainder of the season. In other words, peak levels were not maintained over a considerable period as in the first pattern.

Levels of nutrient uptake on both soils were comparable for nitrogen, phosphorus, potassium, and sulfur; but considerably more calcium and magnesium were taken up by yellow birch on the poorly drained soil than on the well-drained soil. Better annual diameter growth of the test trees was also recorded on the poorly drained soil.

Having established how nutrient gains and losses vary over the season in yellow birch foliage, we are better able to establish acceptable periods for sampling leaf tissue so that variations with time or season can be held to a minimum. This information is necessary for later studies that will investigate relationships between leaf nutrients and tree growth as well as nutrient uptake in relation to nutrient supply in the soil.

Yellow Birch Growth Related to Soil Factors

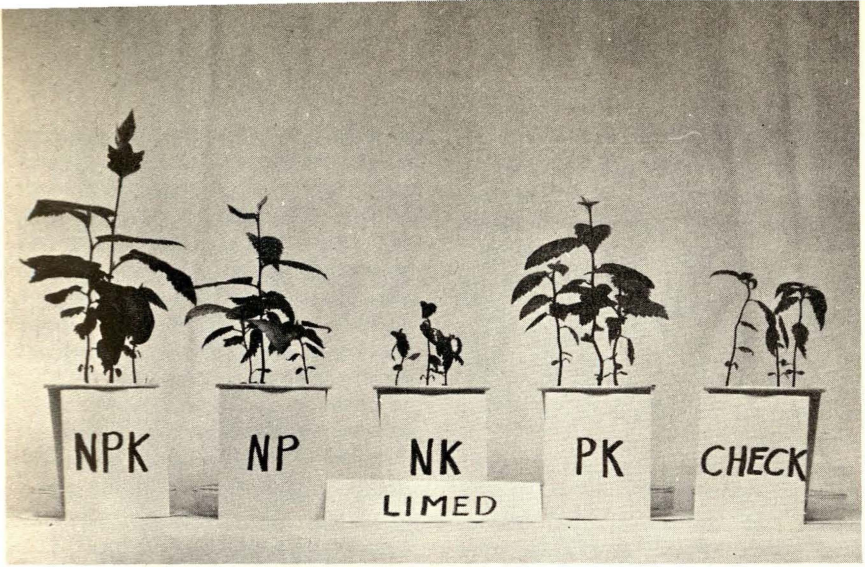
In a preliminary study, samples from six horizons (i.e., recognizable layers formed in the soil by weathering processes) of a well-drained podzol soil, Hermon series, were treated to modify bulk density and aeration. Yellow birch seedlings growing in the treated soils under artificial lighting showed little response to the treatments. Growth and development were primarily related to the soil horizon in which the seedling was growing. Excellent growth was obtained in humus. Smaller and chlorotic seedlings developed in the surface mineral soil layer, whereas little or no growth was produced by seedlings in the subsoil layers. The results suggest that nutrient element deficiencies in the subsoil layers, and perhaps in the surface mineral soil layer, restrict seedling growth.

More recent exploratory work involving additions of nutrient salts to subsoils indicates that root and shoot development of yellow birch can be improved by phosphorus fertilization.

Birch Regeneration

A major study of birch regeneration on the Bartlett Experimental Forest has been completed. The effects of various types of simulated strip clear cuttings on the germination and survival of yellow and paper birch and on light, moisture, and temperature regimes were studied. Shade-cloth screens, 6 feet tall and 20 feet long, were used to simulate the strip cuttings. Seedlings were grown in clay flower pots so that soil composition would be uniform, and so that soil moisture and temperature regimes could be altered. The simulated cuttings and light conditions studied were:

1. East-west strip with the width equal to ½ the height of the border trees (height of the artificial screen above ground), which provided direct sun in early morning and late afternoon, and 80% shade in the middle 6 hours of the day.
2. Same as above but 50% shade in the middle of the day.
3. North-south strip with the width equal to ½ the height of the border trees, which provided 80%



Yellow birch seedlings in variously fertilized subsoil. Best development was in the presence of phosphorus, while poor development occurred when this element was omitted. (Key: N = nitrogen, P = phosphorus, and K = potassium.)

shade in the morning and afternoon, and 2 hours direct sun around noon.

4. North-south strip with the width equal to the height of the border trees, which provided 4 hours direct sun around noon.
5. Northwest-southeast strip with the width equal to ½ the height of the border trees, which provided direct sun in the morning and shade in the afternoon.
6. Large clear cutting, which provided full sunlight.

Germination and survival were closely related to the environments created. In plots where soil moisture was maintained at a high level, germination and survival were high, regardless of light exposure. But when supplemental moisture was not added, germination and survival varied greatly with light exposure. Treatments (1) and (3) offered the most shade and supported the highest germination and survival. Treatment (6) — full sunlight — produced the lowest germination and survival. Soil moisture and temperature also varied with light exposure; highest temperatures and lowest moistures occurred where sunlight exposure was greatest, and vice versa. High and probably lethal soil temperatures occurred on those plots exposed to direct sunlight, but only when the soil was dry. Thus, although light, moisture, and temperature are all important, soil moisture appears to be the one physical factor most important for germination and early survival of the birches.

SPRUCE-FIR

Orono, Me.

This research project concentrates upon the silviculture of spruce, fir, and paper birch as well as investigations of the extent, causes, and impact of animal damage to timber stands in the spruce-fir region. New developments in both animal damage and strip cuttings highlighted the current year's research program.

Sapsucker Damage

Observations taken on the Penobscot Experimental Forest in Maine provided new insights into the effects of yellow-bellied sapsuckers on timber stands. Information was acquired about feeding and damage patterns and subsequent influences of the sapsuckers on tree development, the positions and sizes of wounds causing tree mortality, and seasonal variations in preferred tree species.

Sapsucker damage was found on 17 hardwood tree species, 6 coniferous species, and one shrub. Red maple, paper birch, eastern hemlock, gray birch, and red spruce were the most frequently damaged forest tree species. Sapsucker wounds apparently caused the death or near death of 40% of the red maples attacked. The corresponding percentages for the other major tree species were: white birch 51%; gray birch 67%; and hemlock and red spruce 2% combined.

Past interest in sapsucker damage has been largely concerned with the degrade of sawtimber-size trees. This investigation has revealed a relatively new field of interest that may be of major significance: mortality caused by sapsuckers among trees of less than sawtimber size.

Strip Cutting

Clear cutting, in one form or another, is drawing greater interest from foresters than in the past primarily because this cutting method is suitable for establishing simplified management procedures, regenerating certain desirable species, and utilizing the heavy, fully mechanized harvesting equipment now being developed and tested. Where natural regeneration is used, clear cutting in strips will probably be a promising practice. But the success of this practice will depend to a large extent upon the proper choice of a strip width and method of slash disposal.

A new study now being established on the Penobscot Experimental Forest will explore the feasibility of strip cutting in spruce-fir stands. The study will assess the effects of three strip widths (1, 2, and 3 chains) and three slash disposal methods (burn, remove, and leave in place) on the establishment and development of spruce and fir reproduction. In this study, we hope to simulate the conditions that might be present after harvesting a timber stand with heavy and fully mechanized logging equipment.

EASTERN WHITE PINE

Alfred, Me.

The white pine silviculture project is at present focused mainly on cultural treatments in young stands and on direct seeding. One study in each of these areas of research is reported below.

White Pine Pruning and Branch Growth

Although the growth rate of branches on young white pines appears to be greater after pruning, this is an illusion caused by reduced growth of the main stem. A recently completed study has shown that growth rate of the residual branches is not affected by pruning.

In this study, which was started in 1959, 12-year-old white pine trees spaced 6 and 12 feet apart were pruned to remove about 40, 55, or 70% of their living branch area (cross-sectional area measured about 1 inch from the main stem). Main-stem growth rates were reduced, roughly in proportion to severity of the pruning, but no significant change in growth rate of the branches occurred during a 3-year period at any pruning intensity. Main-stem growth rates recovered almost completely in 3 years. The net loss in volume during the 3 years ranged from 14 to 37%.

When the main-stem growth rates of pruned trees had almost fully recovered, living branch area per unit of stem volume was only 70 to 80% of the normal for unpruned trees at 12-foot spacing. This implies that a considerable portion of the branch area (or crown) of unpruned trees was not contributing to stem growth.

Time and Temperature Relationships in Stratifying White Pine Seed

Three lots of local white pine seed were stratified for various periods up to 90 days at temperatures of 36°, 40°, and 50°F., and then incubated for germination at alternating temperatures of 68° to 86°F. for 40 days. Differences in germination among seedlots, although significant, were too small to be of practical importance. The speed of germination was slightly but significantly higher for seeds stratified at 40° or 50°F. than for those stratified at 36°F. Premature germination occurred among seeds stratified at 50°F. for 60 and 90 days. Nearly full germination occurred after 30 days' stratification, regardless of temperature. The fastest response occurred after 90 days' treatment — over 90% germination in 8 days.

The data indicate that stratification temperature is not critical within the range of 36° to 40°F. The critical factor at these temperatures is time. A minimum stratification period of 60 days at 36° to 40°F. is recommended for seed that is to be sown in the spring. Longer periods up to 90 days will increase the earliness and speed of germination, which is a highly desirable effect because optimum conditions for germination and initial seedling establishment often prevail only in early spring and only for a short time. Stratification temperatures higher than 40°F. are suggested only in circumstances where the treatment period must be shorter than 60 days.

FOREST GENETICS

Durham, N. H.

The genetics project is concerned with tree improvement in several coniferous and hardwood species through selection, provenance testing, breeding, and supporting research — both basic and applied. Two items of research information from project studies are noted below.

Resin-Insect Relationships in White Pines

The development of strains or hybrids of eastern white pine (*Pinus strobus* L.) that are genetically resistant to one or more serious insect pests would be a great boon to growing this species. One of the factors in possible resistance to the white-pine weevil (*Pissodes strobi* Peck) and the white-pine cone beetle (*Conophthorus coniperda* Schwarz) lies in the oleoresins. Resins that remain fluid in an insect wound may repel the insect or reduce its activity; and resins that crystallize probably are inactivated as deterrents to insect attack.

Preliminary tests have indicated that larvae of the weevil and adults of the cone beetle may cope with the resin obstacle in a number of white pine species by secreting substances that induce or accelerate crystallization of resins from the cortical canals. Resins from the xylem canals were not similarly affected. Distinct differences in crystallization reactions were found among 13 species and hybrids tested against the weevil and 18 species and hybrids tested against the cone beetle. Limited data from some of the hybrids suggest that the crystallization characteristics of the cortical oleoresins are under genetic control. If so, we can hope eventually to develop trees in which the resins resist crystallization and thereby confer some measure of resistance to attacking insects.

Inheritance of Timber Form in Soft Maples

The genetic improvement of hardwoods should include the development of genotypes with sufficient apical dominance to eliminate forking and to minimize stem-crook after injury to the terminal shoot.

After 20 years our control-pollinated maple progenies have provided some interesting information on inheritance of good stem form, although the original parent trees were not selected for this character. When these progenies were outplanted as 5-year-old nursery stock, they were cut back (topped) proportionally to their height to determine their ability to develop good timber form after such injury.

A wide variation in percentages of trees that recovered good stem form was found among different parent combinations of red and silver maples (*Acer rubrum* and *A. saccharinum*); particularly noteworthy are the comparatively high percentages of good timber types among the hybrids that had tree No. 60 as the male parent (table 2):

COASTAL OAK-PINE
New Lisbon, N. J.

This project is concerned with the silviculture of the hardwood and pine types in the Coastal Plain and Piedmont of New Jersey, Pennsylvania, Delaware, and Maryland. Progress in 2 of the 25 studies that were active in 1964 is summarized here.

Factors Affecting Yellow-Poplar Site Index in South Jersey

In 1963, a study was started to determine the relationships of various soil and topographic factors to the growth of yellow-poplar, one of the choice forest trees of the New Jersey Piedmont and inner Coastal Plain. The first work was concentrated in stands on the inner Coastal Plain, a strip 15 to 20 miles wide extending about 100 miles along the Delaware River north to Trenton and across central New Jersey below the fall line. In these stands, site indexes for trees 50 years old vary from 70 to 110 feet.

By regression analysis, three soil factors and two topographic factors

Table 2. — *Percentages of trees that recovered good stem form among different parent combinations of red and silver maples*

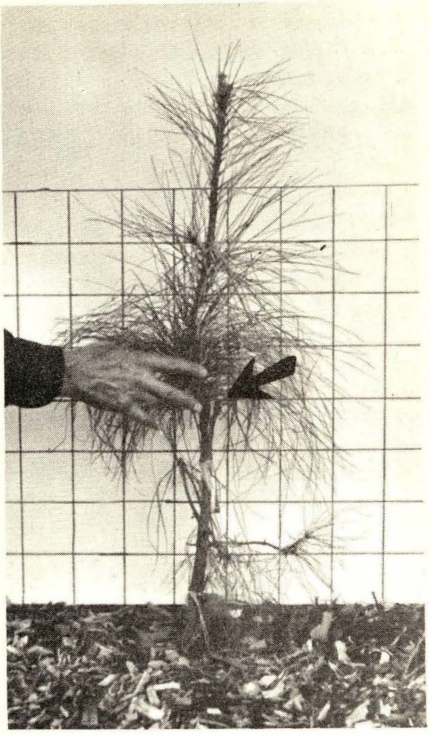
Female parent	Male parent — species and tree number								
	A. rubrum							A. saccharinum	
	28	60	61	62	65	75	303	58	201
A. rubrum									
Tree 64	10.3	16.4	6.4	9.5	2.4	0.0	4.2	—	13.8
Tree 70	.0	9.8	10.4	5.5	8.1	5.0	3.4	10.9	7.5
A. saccharinum									
Tree 58	—	20.0	—	18.0	—	—	—	—	5.1
Tree 201	—	25.6	9.8	—	—	—	—	9.1	—
Tree 202	0.0	21.6	8.0	9.0	—	—	4.8	—	0.0

were identified as the important variables. These were: (1) soil depth to mottling; (2) depth to tight subsoil; (3) clay content of the subsoil (or at the 24- to 36-inch level where a subsoil was not present within 36 inches); (4) topographic position; and (5) surface soil drainage. A regression equation based on these five factors was developed that accounted for about 87% of the variation in yellow-poplar site index in this inner Coastal Plain section of the State.

Selection and Breeding of Pitch and Loblolly Pines for Superior Trees

The West Virginia Pulp and Paper Company and the Station — in cooperation with several State and private organizations — laid the foundation in 1964 for a tree-improvement program involving loblolly and pitch pines. The objectives are to provide: (1) superior loblolly pines for southern Delaware and eastern Maryland; (2) superior pitch pines for different sections of the Northeast; and (3) pitch-loblolly pine hybrids that will be winter-hardy north of the range of loblolly pine and that will outgrow pitch pine. About 30 outstandingly superior trees of each species were selected, and scions from them were grafted on seedlings of the same species. Although grafting success by clones varied from 0 to 97%, the overall success, as of September, was about 60% for pitch pines and 71% for loblolly pines.

Except for the few clones that generally failed to graft, 10 to 20 grafted seedlings of each loblolly pine clone and 8 to 10 grafted seedlings of each pitch pine clone were moved in the fall of 1964 to a breeding orchard site near our New Lisbon headquarters. Present plans are to replace the grafting failures and any transplanting failures next year. When these seedlings reach the cone-bearing stage, controlled intra- and inter-species pollinations will be made, and the resulting progenies will be outplanted and evaluated for growth vigor, winter hardiness, and tree form.



A grafted loblolly pine seedling. Stub of the rootstock leader (arrow) and the amount of new growth on the scion are especially apparent.

ALLEGHENY HARDWOODS
Warren, Pa.

The project on silviculture of Allegheny hardwoods has two distinct facets: (1) silvicultural studies in natural stands and in reforesting old fields, cutover land, and burns — with major emphasis on black cherry — and

(2) planting studies with many species on coal-mine spoils. This report highlights one study dealing with the silviculture of black cherry, and two closely related studies on mine-spoil planting.

Pruning Open-Grown Black Cherry

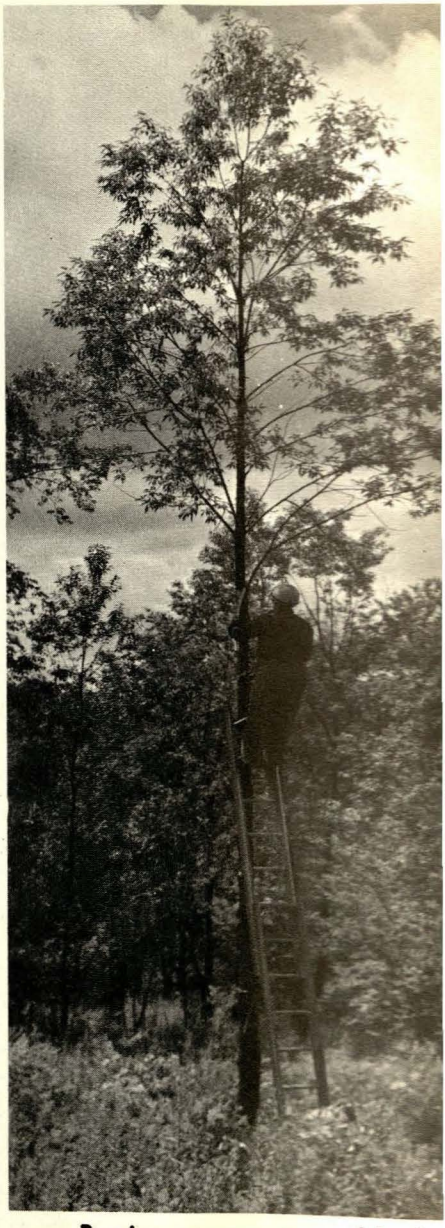
This study, established in 1962, deals with trees of good form in the 4-, 5-, and 6-inch diameter classes growing in open stands and having live crown ratios (before treatment) of at least 75%. Twelve trees per treatment were pruned to 25, 50, or 75% of total height, or were left unpruned as controls.

Diameter growth during the first year after pruning was severely reduced by the 75% treatment: the average increment at breast height was 0.10 inch, as compared to 0.23 to 0.28 inch for trees that were pruned less drastically or left unpruned. Because this growth reduction may be temporary and because it should improve the form class, it probably will not be as harmful as the epicormic branching that also occurs. The trees pruned to 75% of total height averaged 35 epicormic branches each after 1 year; those pruned to 50% of total height averaged fewer than 2 branches each, and nearly half of all branches tallied under this treatment were on one tree.

The study also included trials of two methods for pruning higher branches: extension poles on the saw, and a light 16-foot ladder. For the conditions of this study, the ladder was much easier to use, and it enabled the pruner to make closer, neater cuts. Because cherry bark is easily damaged, the top rung of the ladder should be cushioned against the tree.

Hybrid Poplars for Mine Spoils

In earlier experimental plantings established by Pennsylvania State University on mine spoils, one hybrid poplar clone was included, and it outgrew all other species. Since only one



Pruning an open-grown black cherry tree to 50% of total height (18 feet in this instance). This treatment has prospects of greatly increasing the ultimate value of such trees.

clone had been used in those early plantings, a screening study was started in 1961 in which some 60 clones were planted on different types of bituminous spoil. A number of these clones have grown well except on extremely acid materials, and are now in production in the State nurseries for bituminous mine-spoil reclamation. In 1964, 30 of the more promising clones were planted on various anthracite spoils. Despite a dry summer, first-year survival has been generally good on the anthracite strip-mine spoils, but has been poor on the deep-mine spoils.

Revegetation Guide

A major undertaking in 1964 was the preparation of a Guide for Revegetating Bituminous Strip-Mine Spoils in Pennsylvania. This publication, to be released early in 1965, is a joint effort by a committee representing seven cooperating agencies, with the Station providing the chairman. It brings together the most up-to-date information on spoil revegetation from all sources, and covers spoil reclamation for various purposes by use of both herbaceous and woody plants.

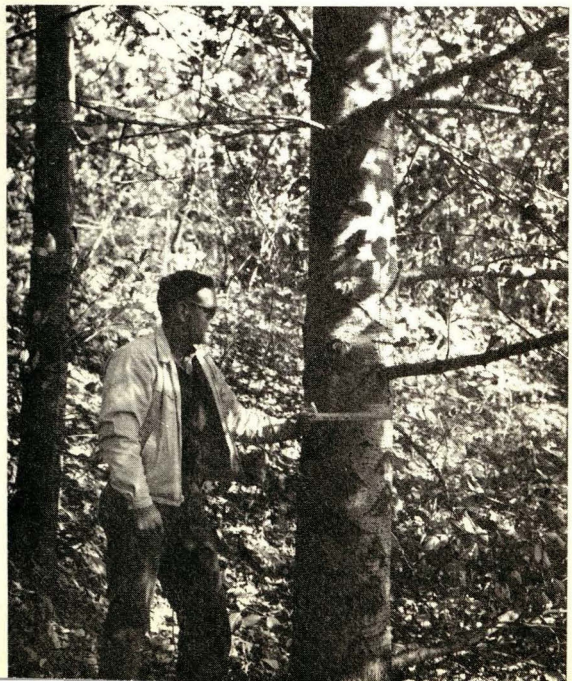
NORTHERN APPALACHIAN HARDWOODS

Parsons, W. Va.

The research program of this timber-management research project covers the silviculture and management of the important northern Appalachian or mountain hardwood species, including studies of site relationships, silvicultural systems, growth and yield, and regeneration. Some of the more important information acquired at this project during the past year is described below.

Improvement in Log Grade with Increase in Tree Size

The quality of hardwood lumber is positively related to the size of the log from which it is sawed. However, the proportion of quality lumber in a log is also affected by factors such



Excellent growth of a hybrid poplar clone on bituminous mine spoil 18 years after planting. This performance prompted the recent establishment of extensive trials of hybrid poplars in both the bituminous and anthracite regions of Pennsylvania.

as the number and size of clear cuttings, the amount and distribution of rot or other internal defect, and the degree of log crook or sweep. In unmanaged, undisturbed forests, these factors tend to vary rather consistently among species.

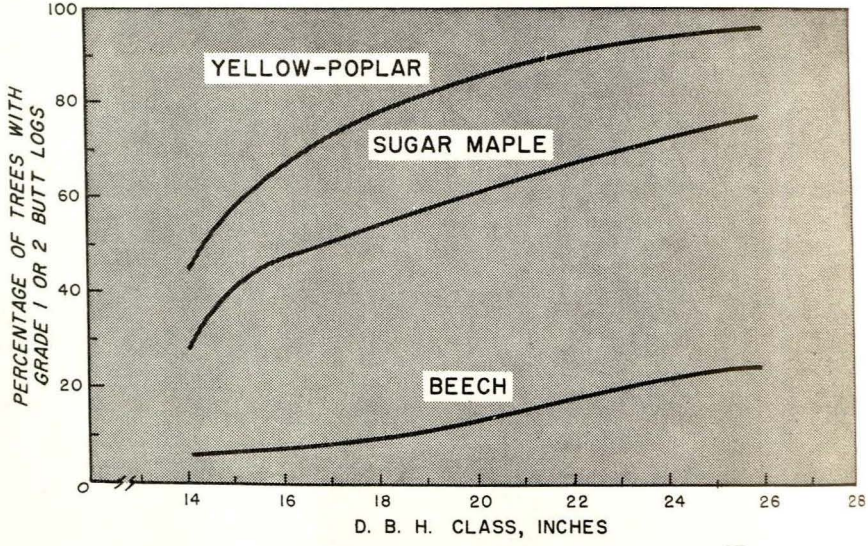
In an attempt to define natural grade tendencies, a study was made of six Appalachian species in undisturbed sawtimber. The factory-lumber log grade of the butt log was used as a criterion. The six species were yellow-poplar, sugar maple, beech, northern red oak, chestnut oak, and white oak. Well-defined relationships between tree diameter and the percentage of trees that have butt log grades 1, 2, and 3 were developed for each species. Marked differences in grade were exhibted among species. For example, the percentages of trees with butt-log grades 1 and 2 were considerably higher for yellow-poplar than for sugar maple and beech, in that order.

These results can be used, in some measure, to assess the potential quality yields from unmanaged mountain hardwoods, based upon an estimate of average stand diameter.

Effects of Clear-cut Openings on Epicormic Branching

A study was made of epicormic branching on trees bordering 12-year-old openings cut in hardwood stands in West Virginia. Large pole-size trees and sawtimber trees of three species were observed: northern red oak, black cherry, and yellow-poplar.

The study showed that openings effect an increase in epicormic branching. Epicormic branching on border trees differed significantly among the three species, and was greatest on red oak and least on yellow-poplar; black cherry had intermediate branching. Epicormic branching increased with



The relationship between tree diameter and the percentage of trees with factory lumber butt-log grades 1 or 2 for yellow-poplar, sugar maple, and beech.

distance above the stump. It was least on dominant trees and became increasingly greater with decreasing dominance.

Under no conditions was epicormic branching on yellow-poplar a problem on the first log. Intermediate and overtopped black cherry trees suffered slight degrade in the first log; dominant and codominant trees did not. Red oak of all crown classes suffered some degrade in the first log.

Aerial Spraying of Poor Site Hardwoods with 2,4,5-T

The aerial application of silvicides to poor-site hardwood stands shows promise of being an effective aid in stand conversion (hardwood to conifer) in West Virginia. A study that used a 2,4,5-T aerial application on four 8-acre plots bears this out. Before the silvicide was applied to the area, the slow-growing hardwoods were completely logged off two of the plots in June 1963; the stand was left intact on the other two plots. A mixture of ⅓ gallon of 6 pounds acid equivalent per gallon iso-octyl ester of 2,4,5-T and 4.5 gallons of No. 2 fuel oil was applied by helicopter in mid-August of 1963 at the rate of 5 gallons per acre. A check of the area a year later showed:

1. The silvicide had deadened the small trees left after logging but had not prevented the stumps of cut trees from sprouting. If the treatment had been made a year or two later, when stump sprouting would have been complete, treatment probably would have been more effective.
2. On the uncut plots, the deadening effect on the overstory was good. Ninety percent of the oaks, which comprised most of the stand, were killed or severely defoliated. Scattered red maple, black locust, and basswood were also satisfactorily affected. The hickories, serviceberry, and *Crataegus* spp. were only slightly damaged, while the scattered pitch and Virginia pine showed no effects from the treatment.
3. Not enough of the silvicide reached the understory on the uncut plots to kill many of the small stems in this stratum.

■

FOREST FIRE

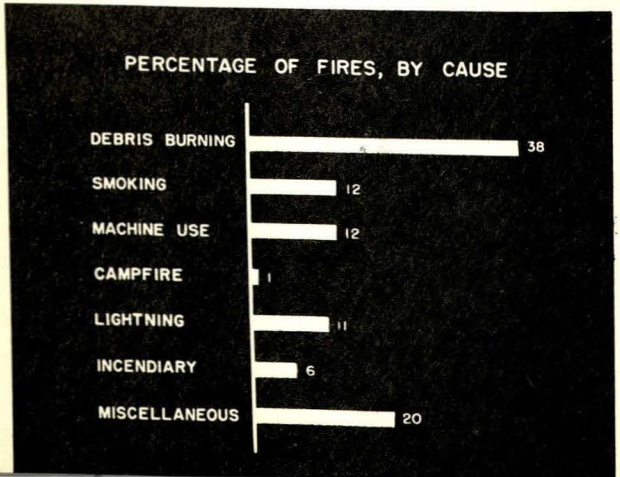
DURING 1964, additional work was done on the two fuel-moisture studies reported last year. This was in the nature of rounding out and summarizing the data as they relate to the new National Fire Danger Rating System. Also in 1964, an intensive study of fire causes was begun.

FIRE CAUSES

Nearly 10,000 forest fires occur in the 12 Northeastern States every year. Most of these fires are man-caused, so the need for improved fire prevention is obvious. As a first step toward improved prevention, more reliable information is needed on how fires are started and who starts them.

There is general agreement that an intensive investigation of a randomly selected portion of fires would probably provide reasonably reliable information on these points. Four states — Maine, Rhode Island, Pennsylvania, and New Jersey — began studies of fire causes in 1964. So far, preliminary summaries are available only for Maine.

Of the 171 fires intensively investigated in that State, causes were identified positively for 88 (51%) and probably for 66 (39%). The causes of the remaining 17 fires (10%) were not identified. The proportion of fires attributed to the various causes differed considerably between the positively and probably identified groups. This was expected because fires that originate from certain causes are rather easy to identify positively, whereas other fires leave some room for question. We believe that by using all the positively and probably identified fires in the sample, a reasonably good estimate may be made of the causes of all fires. On this basis, debris-burning was responsible for three times as many fires as any other single cause. Smoking, machines, and lightning — all about equal in occurrence — were the next most important causes of fires.



Of 171 fires that occurred in Maine during 1964, 51% were positively identified as to cause, and for 39% the probable causes were identified.

REORGANIZATION OF FIRE RESEARCH

Early in 1965 the one-man fire research project at the Nortseastern Station will be discontinued. Some of the work that is being done in the Northeast will be taken over and continued by a reorganized fire-research project at the Lake States Station in St. Paul, Minn. Work of the St. Paul project will be directed primarily toward improving fire-control systems throughout the northern United States east of the Rockies — including the Lake States, Central States, and Northeastern regions.

Also, a fire-research project of the Central States Forest Experiment Station, located at Columbia, Mo., will concentrate on fire-damage-appraisal methods for tree species in the eastern United States — including the Northeastern region.

FOREST ECONOMICS

ECONOMICS OF TIMBER GROWING

RESEARCH in the economics of timber growing has been limited, and we have not been able to make economic evaluations of many management practices in most forest types. Even so, enough has been done to allow some generalization about investments in timber growing.

Timber Investments

From the financial standpoint, merchantable and near-merchantable stands are the most important part of timber property. This is where most of the current timber value is concentrated, and the management of these stands is crucial to financial success. A basic decision for these older stands is when to harvest them. From a dollar standpoint it is best to hold mature timber only as long as it is increasing in value at a reasonable rate.

A reasonable rate may be anywhere from 4 to 10% depending on the quality of other investment opportunities available to the owner. Through use of present-day inventory and growth-projection techniques, it is not difficult to estimate current value growth rates accurately. Some owners may wish to hold stands longer, or to harvest them earlier than is indicated by their minimum acceptable rate of value growth. They do so in order to spread income more evenly over the years or to provide a more stable level of production for a processing plant.

Our studies in establishing and managing younger stands indicate that there are great differences in investment prospects from one situation to the next. In general, stands on good sites with at least moderate stocking offer the best returns to management.

Cultural treatments in these stands often return better than 5% on costs, and such treatments should get first priority in the timber-stand-improvement schedule. Pole stands are usually better investments than seedling-and-sapling stands or areas in need of regeneration primarily because costs carried forward at compound interest build up so rapidly as the number of years to harvest increases. Perhaps the most frequent investment error has been to place too much emphasis on obtaining regeneration on poor sites. These investments in managing poorer sites sometimes lead to absolute losses and almost always have shown up poorly when compared with investments in managing better sites.

Project Progress

During the past year we published a bulletin on weevil control in white pine (U. S. Forest Service Research Paper NE-19), which contains specific guides for setting up a control program. Weevil control seems to be a fairly useful and reliable practice in many circumstances, as the bulletin points out. We also published this year a bulletin outlining a new system for appraising timber-investment projects that takes uncertainty into account by simulating investment outcome under various assumptions about uncertain factors (U. S. Forest Service Research Paper NE-23). Those who prepare project evaluations may find this new approach valuable.

Also during 1964 we:

- Added a second economist to the project.
- Concluded our studies of white pine blister rust incidence.
- Began developing a computer program for interest-rate computation.
- Began revising a guide for timber-stand-improvement evaluations on National Forests.
- Completed revision of a pamphlet on white pine mensuration data.
- Began a study of timber-stand-improvement practices in the oak types.

And our cooperators:

- At Harvard University completed work on a timber-management simulator program designed to test rapidly the value of various management strategies.
- At Syracuse University completed a white pine growth and financial maturity study.

GOVERNMENT FORESTRY PROGRAMS

Government Assistance for Planning and Timber Stand Improvement

This project aims to provide economic information that will aid governmental planning units in their forestry decisions. Such aid can be provided in several ways. The most useful way is to give planning units economic evaluations of the alternatives facing them. This is the approach used in a study of the economics of public assistance to private landowners for major forestry practices in Pennsylvania.

The purpose of this study is to determine the financial prospects of funds invested in planting and timber stand improvement when public assistance is provided to private woodland owners. Such assistance can take the form of cost-sharing payments under the Agricultural Conservation Program or technical forestry assistance under the Cooperative Forest Management Program. Financial prospects of various practices will be evaluated in terms of (1) the potential economic returns to the landowners who undertake the practices and (2) the costs incurred by both the landowners and

by the public through assistance to the landowners.

Regional Demand Studies

Our economic analyses have been directed at evaluating alternatives facing forest land managers — landowners, Federal and State officials, and others. Now, to insure that the information is useful for evaluating alternatives, we are trying to define the economic framework within which woodland owners are making their forestry decisions.

We have postulated that the most influential economic factor to woodland owners is the demand for the products that they can produce. Therefore our immediate effort in developing a dynamic picture of the economic framework within which the woodland owner operates is concerned with demand. In a dynamic regional demand study, some of the following questions are particularly important:

- What woodland products are being marketed?
- Where are they being marketed?
- What are the alternatives open to individual woodland owners?
- What changes are taking place?

The Northeast has large and varied timber resources. But not all of these are subject to the same degree of economic demand. The economic demand for even a single species may vary considerably from place to place within the region because of the location of wood-using plants.

In some areas, restrictions on the amount of timber that could be supplied have apparently limited the development of economic demand. This is particularly true in the urban fringe areas, where some woodland owners prefer to hold their timber for aesthetic or other purposes rather than market purposes. It is also true in some areas where forest land is held for outdoor recreation.

These factors change in time, too. The decline of the wooden box industry in New England has reduced markets open to woodland owners in the white pine areas. On the other hand, expanding markets for wooden pallets have increased the markets available to woodland owners in other parts of the Northeast. Work we are doing in connection with comprehensive river-basin studies shows that there will be significant changes in the locational pattern of timber use in the Northeast.

Data that we have developed for the comprehensive river-basin studies is to be refined and organized to assist decisions of governmental planning units. This work in the immediate future will be largely descriptive, but will lead into analytical studies of program alternatives.

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FOREST SURVEY

RESURVEY OF WEST VIRGINIA

THE Timber Resources of West Virginia report was distributed late in 1964. It is longer than any of our previous Survey reports — 123 pages. This report is also a first in Forest Service resource bulletins in two respects:

1. It contains a complete set of State, geographical sampling unit, and county tables under one cover — 98 tables in all. Thus the report is expected to meet the demands of managers and planners at all levels.
2. It contains, for the first time among such publications, calculated sampling errors for most of the major breakdowns of timber-resource data: individual stand-size classes, individual species, individual diameter classes. Thus decision-makers can know how much confidence to place in the information. Previous resource reports presented sampling errors for totals only and charts from which readers could estimate errors for individual items.

RESURVEY OF MARYLAND

The IBM computer program developed and used for the West Virginia survey was complex but restrictive. It was almost completely scrapped; and in December, a new and more flexible program was completed that will accept various sampling designs as well as the one used for Maryland.

Output of estimates and their associated sampling errors of Maryland forest areas, timber volumes, and timber growth was expected early in 1965. A timber resource report similar to that for West Virginia will be prepared, and the publication is expected to be ready for distribution by the summer of 1965.

Maryland was divided into five geographical sampling strata. Additional sample field plots were taken to provide more precise county estimates of resource data within all but one of these strata. The Station's forest-survey crews remeasured 100 plots that were established 11 to 14 years ago on the initial survey and established 284 new plots. Crews from the Maryland Department of Forests and Parks remeasured 85 initial plots and established 252 new plots. Thus the new estimates of forest area and timber volume will be based on 721 new and remeasured plots, and the estimates of timber growth will be based on the 185 remeasured forest plots.

RESURVEY OF PENNSYLVANIA

This resurvey required the coordinated effort of Region-7 personnel for National Forest land, Pennsylvania Department of Forests and Waters personnel for State forests, and the Station's forest-survey personnel for all other land within the State and for the entire resurvey as well.

The National Forest land was set up as one geographical sampling unit, and sampling was greatly intensified.

National Forest crews remeasured all the 159 initial forest-survey plots on National Forest land and established 3,000 new field plots.

In cooperation with the State Forester's staff, three sampling units were set up to include all State forests within the State. State crews remeasured all initial forest-survey plots (175) that fell on State forest land. They also intensified the survey in their three sampling units by establishing 450 new field plots.

All other land in the State was divided into five sampling units. The Area Redevelopment Administration financed the establishment of an additional 500 field plots in these units to intensify the survey so as to provide local data of greater reliability.

All field work — a grand total of 5,975 field plots — was completed by the end of November 1964. All plot, point, and tree data, and the supplementary data, will be punched into IBM cards. Later the IBM 7094 7040 computer system at Yale University will digest all this information and produce output similar to that for West Virginia and Maryland. A timber-resource report based on these estimates is expected to be available for distribution before the end of 1965.

RESURVEY OF VERMONT

Vermont will be the first State in the Northeast to be resurveyed according to Nationwide Forest Service standardized field instructions and field forms. A new 3-digit coding system for all tree species found in the United States will also be used for the first time. All genera and species were arranged alphabetically, and a sequence of codes was assigned from this arrangement.

Again there will be cooperation with Region 7 and with the Vermont Department of Forests and Parks. Both will intensify the sampling on their respective lands and will provide crews to take the sample plots. Both the photo interpretation and field sample plot jobs will be completed during 1965.

COUNTY STATISTICS

Ever since the Forest Survey was started in the Northeast in 1946, innumerable requests have been received for county forest-area and timber-volume statistics. The best estimates available were supplied previously with a warning that they may be unreliable if not combined with several other counties. Now, with the highly sophisticated computer program in use, county statistics for the resurvey and their corresponding sampling errors can be supplied to all those interested in such data.

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FOREST RECREATION

WARREN LABORATORY

THE regional research program in forest recreation advanced along three fronts in 1964: studies of forest visitors, recreation management studies, and recreational impacts on soils and vegetation. The establishment of four new studies has taken us into Maryland, Maine, Massachusetts, Connecticut, and New Hampshire. These same efforts also represent a movement into new research directions of forest-recreation management on private lands, short-range trend analyses of the demand for forest recreation, and critical study of the outdoor values of forest visitors.

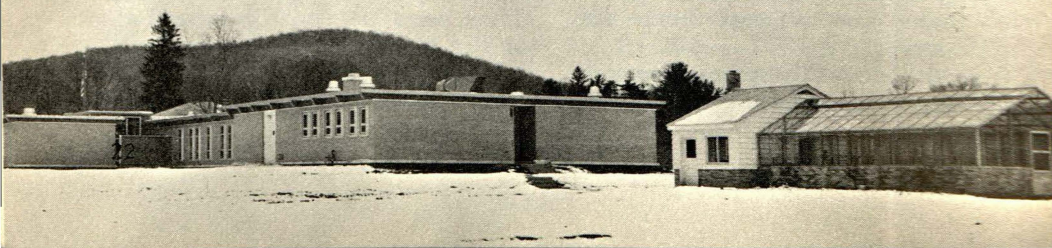
Recreation Demand

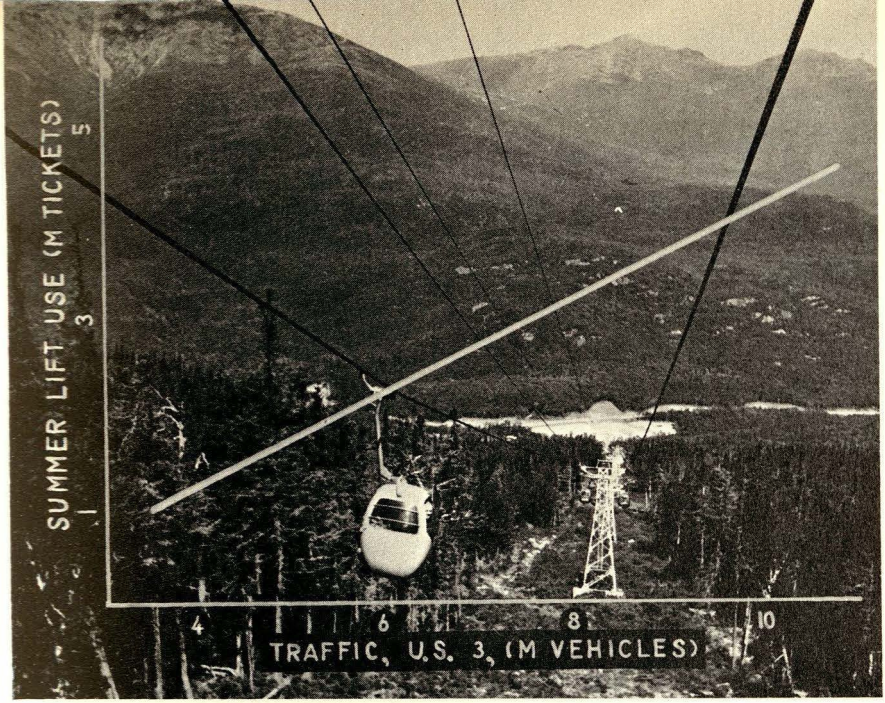
A major undertaking in the study of forest-recreation demand was begun in 1964 with a volunteer panel of 422 forest visitors who will provide us with detailed information on changes in their leisure-time interests, income level, expenses, home-ownership patterns, and family size over a 5-year period. Each panelist has already participated in a fairly lengthy interview covering these same topics. The analysis of long-term trends in recreational participation will be partially controlled to assure equal recreation opportunities; then the analysis will be evaluated according to a variety of measures such as the origin, intensity, variety, length, and dimension of each panelist's outdoor involvements.

A major obstacle to much demand research is the inadequacy of data used in making projections. Valid recreation-use statistics are the exception rather than the rule. Forest visitors engage in several different activities during each visit; they make several exits per visit and several visits per season; and often they do not have to pay or otherwise register their visits. As a result, visitors may be counted too many times, or not at all. To overcome these obstacles, agencies administering recreation lands have relied on a combination of measuring tools; and such agencies temper their final figures by various judgments as to what constitutes a normal annual increase.

Two studies begun in 1964 aim to

The new Forest Recreation and Wildlife Laboratory near Warren, Pa.





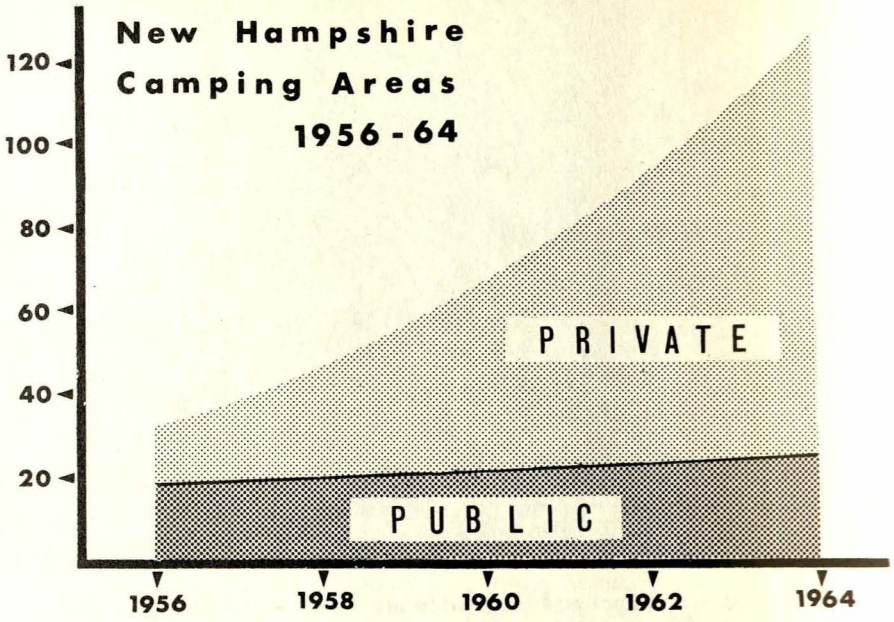
Estimates of regional and State-wide use of recreation facilities, such as this ski lift on Wildcat Mountain in New Hampshire, can be obtained quickly and cheaply by counting the highway traffic at selected locations.

improve methods for gathering recreation statistics. Cooperative studies have been undertaken with State agencies in Maryland and New Hampshire to develop reasonably accurate methods for measuring current recreational activity at State parks, public beaches, private recreation developments, and recreation-related industries. One study nearing completion in New Hampshire provides a series of regression formulae for estimating regional and State-wide use of golf courses, overnight lodging accommodations, roadside tourist enterprises, and forest-oriented activities such as use of ski lifts and public beaches.

Recreation on Private Lands

A descriptive survey of the people who own and visit New Hampshire's 108 privately-developed campgrounds was started and completed during 1964. Undertaken cooperatively with the New Hampshire State Planning Project, the survey describes reasons for the rapid growth of the State's private campground industry, shows the range of investments and returns for these enterprises, and assesses the industry's future as viewed by the campground owners and operators.

The camper-survey portion of this same study reveals that private camping areas have sizable markets of their own in addition to providing overflow accommodations for the crowded public campgrounds. Thirty-six percent of the visitors who returned questionnaires stated a definite preference for the private developments. Another 37% expressed equal preference for public and private areas, and 20% said that they preferred public campgrounds.



Privately developed camping areas in New Hampshire have expanded greatly in recent years, and today there are about four times as many privately developed areas as public in the State. However, the public camping areas are generally larger and can accommodate more family units.

The group of campers that expressed a preference for private developments seemed to be comprised of individuals who were less experienced at camping and more socially involved in their camping. Campers who prefer public developments have a generally negative attitude towards the attraction, development level, appearance, and available activities of private campgrounds.

Soil - Plant Relations

A second season of camper use on study plots in an Allegheny National Forest campground produced marked changes in vegetative composition of ground cover. Several campsites demonstrated a strong reversal of the previously noted decline in vegetative density. Areas that were made barren by last year's recreational pressures have become green again in the face of continued heavy use and an exceptionally dry growing season. The natural encroachment of durable, tolerant plants has actually reduced the extent of barren ground in campsites. At the end of the 1963 camping season the study sites had received an average of 230 camper-days of use, and exhibited an average of 39% barren ground. The 1964 camping season contributed another 264 camper-days, on the average, while barren ground decreased to an average of 37% of the site.

SYRACUSE CAMPUS

Models to Describe Demand

One phase of the cooperative research program with the State University of New York College of Forestry at Syracuse covers the investigation of models that may be useful in predicting recreation demand. A study that involves Adirondack campgrounds will determine if average number of days use per campsite can be predicted from a knowledge of a given campground's physical environment. Factor analysis, a statistical tool for attaining scientific parsimony, is being used on 62 site variables in an attempt to develop a mathematical model to describe campground and nearby recreational environment. If a model should be perfected, multiple linear regression analysis would be used to determine whether or not the model is correlated with intensity of campground use. Gravity models involving transportation systems, distance factors, and population-density data are also being explored as possibilities for predicting demand.

These studies are not necessarily aimed at obtaining predictive mechanisms that will have immediate application for management. However, investigation of underlying structures within the recreation-demand phenomena have been given first priority in order to provide a foundation and direction for cooperative and graduate research.

Design and Analysis of Demand Experiments

Because recreation management and research rely considerably on questionnaire data for decision making and hypothesis testing, a cooperative study with the College of Forestry and the New York State Conservation Department is investigating what survey methods, experimental designs, sampling procedures, and analytical techniques must be used in recreation survey experiments to obtain reliable and valid results at least cost. Questions being used in the various survey methods cover a broad range of recreation-demand factors such as expenditure patterns, motivations, preferences, and opinions regarding facility designs and management procedures, sociological characteristics, and residence-zone distributions of users. These subjects will be investigated in depth in future cooperative research.

User Demands vs. Management Concepts

Results in a 1964 personal interview survey on car access to Adirondack campgrounds indicated that 48% of the respondents wanted all campsites as close as possible to the lake, 42% felt that campsites should be partially screened from the lake, and 10% indicated that campsites should be completely screened from the lake. Other recreationists feel that campsites should not be anywhere near the lake and that the shoreline vegetation should be preserved in its natural condition. Multiple-use recreation concepts are being developed to assist managers in resolving user-demand conflicts such as this between practical and esthetic values.

User preference patterns undoubtedly are influenced by the public facilities that are available. However, many of these facilities were not designed to serve present use intensities and as a result many natural environments are deteriorating. Thus preference patterns often are not correlated with sustained resource-management concepts. The problem of sustaining the unique values of natural forested environment may be possible only if public managers refrain from trying to give certain user groups everything they say they want. In many respects this may be more of a poltical problem than a technical problem, but the search for possible solutions is one of the responsibilities of our research.

Effect of campsite location on the esthetic quality of a lakeshore: A, campsites located a few feet from the shoreline; B, campsites screened from the lake by natural vegetation.

WILDLIFE HABITAT

SINCE its inception 5 years ago, the habitat research project has devoted a major effort to problems in habitat-timber relations. This was done because of the apparent close relationship between management of forest land for timber production and management for game — especially in the use of cutting practices — and because of the opportunity provided by the established, broad geographical base of timber management in the Northeast. There are many examples in timber management of the favorable influence of gross changes in the habitat on game species and game populations. But in most of these instances the impact on wildlife was not planned and the changes resulted in an unmanaged habitat with little possibility of control over the kind and amount of game produced. About all that remained in such instances were game regulations governing the harvest of species that respond best to an unmanaged habitat.

The purpose of research studies in habitat-timber relations is to determine the influence on game of selected timber-management practices, and then to determine how these practices can be adapted or modified in a coordinated plan for the production of both resources.

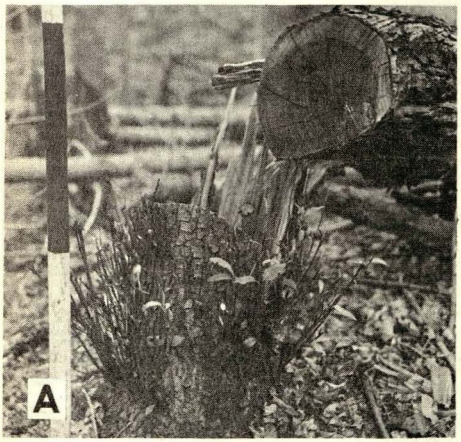
CUTTING FOR BROWSE AND TIMBER

One timber-management practice now under study for its value to wildlife is timber stand improvement in poletimber stands for improved growth and quality of selected crop trees. In this instance the practice has been modified from that of girdling the competing stems to felling all stems except the crop trees, thereby providing a greatly expanded source of deer browse. An attempt is made in cutting and felling the trees to leave a portion of the stem attached or hinged to the stump to prolong the life of the tree for the production of deer browse.

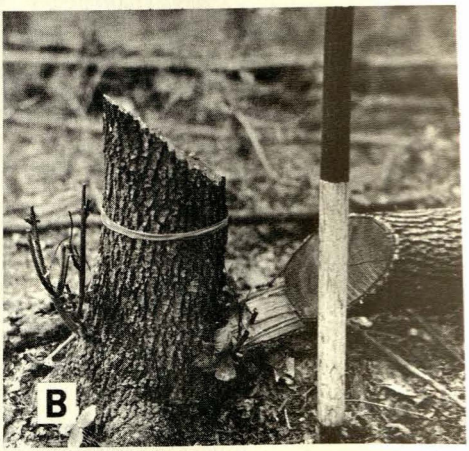
The Station and Region 7 are cooperating in this study on the Allegheny National Forest. Four 10-acre blocks in 40 - 60 year-old Allegheny hardwoods were each cut to a residual basal area of 80 square feet per acre. The production of browse in pounds per acre from tops and stumps will be measured annually for several years. Utilization by deer will be measured twice each year: for the dormant browse consumed in winter and for that taken during the growing season. It is already apparent from first-year measurements that the heaviest browsing is on stump sprouts produced in the first growing season. Preliminary analysis indicates a rather light browsing in spring and summer on the tops, assuring a carry-over of browse into the second winter.

Another study, closely related to this one, involves the same cooperators. Its objective is to determine the browse-producing capabilities of stumps of nine hardwood species. Individual tagged stumps will be observed annually for several years for the production — and utilization by deer — of sprout browse. Although utilization of sprouts during the first growing season was found to be ex-

Deer-browse production from timber-stand improvement is being studied in Allegheny hardwood forests. All trees except the crop trees are felled in winter to provide new sources of browse from stumps and tops. The practice is more costly than the usual girdling to relieve competition.



Hardwood stumps are generally a good source of deer browse. This 8-inch black cherry stump (A) produced 122 sprouts the first growing season, and 118 of these were found to be browsed.



Production of stump sprouts varies with the species and with the diameter of the stump. This small white ash (B) yielded 10 sprouts, all of which were browsed.

Red maple sprouts are the preferred deer browse. This 6-inch stump (C) was very productive: Of the 116 sprouts produced, 106 were browsed.

tremely high for several species, most browsing by deer appears to be wasteful. It is generally limited to a relatively small section of the sprout, which then dies back part way or all the way. Sprouts are seldom browsed more than a few inches back from the tip, yet a chemical analysis for the crude protein content of the twigs of several of these nine species collected at other locations revealed no great decline from the level of protein in 2-inch twig tips to that in 10-inch sections immediately below the tips.

RESPONSE OF SEEDLINGS TO BROWSING

Commercial hardwood reproduction is an important source of browse for deer in the Northeast. Successful regeneration of these species is therefore important to both wildlife and timber management. The question is: How much browsing can these seedlings tolerate and still continue to be a source of browse and future timber?

A 5-year study to determine their range of tolerance to browsing began in 1961. Black cherry, white ash, sugar maple, and red maple were the species selected. Eight clipping treatments were applied annually to simulate various browsing intensities.

Mortality of seedlings at all levels of clipping was negligible after 4 years. Red and sugar maple appear to be especially tolerant — even to heavy clipping. Form in these two species was not greatly affected; height was reduced in some treatments, but in general the differences were not important.

Black cherry and white ash seedlings frequently responded to clipping by producing fast-growing sprouts from the root collar, but the original stems often survived, resulting in multiple-stemmed seedlings. Hence poor form was prevalent in these species. But sprouts also developed in unclipped check seedlings, so poor form cannot be attributed entirely to clipping. The growth of sprouts in black cherry and white ash served to partly offset losses in height due to clipping, so that differences in height were not important. Trends have appeared. As the intensity of clipping increases, we find:

- Higher browse production in white ash and sugar maple.
- Somewhat lower browse production in black cherry and red maple.

■

WATERSHED MANAGEMENT

DURING the past year, the four watershed-management projects continued their programs of stream-gaging, calibrating and treating watersheds, and writing results. They produced a record of 17 publications this past year, which pretty well cleaned out the files, and left for this report a description of the immediate field work under way.

WATER YIELD IMPROVEMENT — NEW ENGLAND

Laconia, N. H.

Watershed Calibration

Hubbard Brook Watersheds 1 to 3 have been calibrated and are ready for treatment. We feel confident that we can statistically evaluate the significance of an increase of 2.8 inches or more in streamflow the first full year after treatment and an increase as small as 0.7 inch during the growing season.

Two of the watersheds will be treated in the fall of 1965, and one will be held as a control. One of the treatments will be a complete clear cutting of all woody vegetation; this is to get a benchmark of the greatest summer flow possible by virtual elimination of transpiration. In the other treatment, the watershed will be strip cut, removing 50% of the trees. Strips will be oriented so as to minimize snowmelt.

Soil Moisture and Temperature

Soil moisture and temperature studies are under way on three ½-acre plots with completion of access-tube and thermocouple installations at 24 locations. Moisture is determined by the nuclear-probe method down to 4 feet. Soil temperature is measured only in the upper 12-inch layers. Both

A neutron meter that enables researchers to measure soil moisture in difficult mountainous terrain.

measurements are aimed at detecting changes in soil moisture and temperature from clear cutting and partial cutting treatments anticipated next winter.

Open House

To commemorate the 10th anniversary of the selection of Hubbard Brook for watershed research, an open house was held at the Experimental Forest in October. U. S. Senator Thomas J. McIntyre and Forest Service personnel addressed a group from West Thornton and other neighboring New Hampshire towns, from local, State, and Federal organizations, and from educational institutions.

Personnel

For the first time in 3 years our Hubbard Brook professional staff is up to its full complement of three persons. Raymond E. Leonard transferred to the cooperative Syracuse Project following 1 year educational leave at Yale where he majored in forest meteorology. Anthony C. Federer, one of our former summer students, who received his Ph.D. in June at the University of Wisconsin with a specialty in soil physics and meteorology, replaced Leonard.

STREAM REGIMENS — NEW YORK

Syracuse, N. Y.

The Sacandaga Watershed Investigation

A program of continuous forest protection in the Adirondacks from 1912 to 1950 has been correlated with a decrease in average annual dormant season and April runoff. As the forest density and crown cover of conifers increased during this period, average annual streamflow decreased 7.72 inches, primarily because of the 5.18 inch decrease in dormant-season runoff. April was the only month that showed a large enough decrease in runoff to be statistically significant — 2.98 inches. Also, the average length of time it took for the most concentrated one-half of the annual streamflow to run off increased by 19 days — from 67 days to 86 days.

Evaluation of Flow Interval Techniques

Watershed data from the Parsons, W. Va., clear-cut and control watersheds are being subjected to the flow-interval analysis, developed at this project, to determine if the clear cutting influenced the length of high- and low-flow periods. These data will be analyzed on the 1620 computer at the Syracuse Computer Center.

Solar Radiation Relationships

Four climatic towers have been erected in a 40-year old pine plantation at the Pack Forest for a study of short-wave radiation reflected by the canopy. Radiometers will be mounted on a cable track between the towers so that both incoming and reflected short-wave radiation may be measured at varying times and locations above the plantation.

Snow Interception by Conifers

Also at the College of Forestry Experiment Station, small conifers will be weighed at intervals following snowfall to determine the amount of moisture withheld by the canopy, and the disposition of the intercepted snow.

MUNICIPAL WATERSHEDS

New Lisbon, N. J.

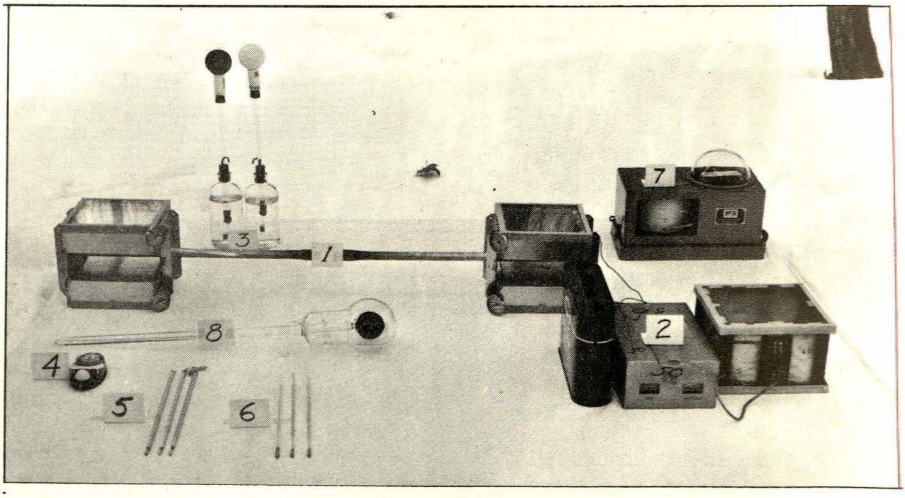
Radiation Measurement

One of the several methods proposed for extending watershed-research results to the wide variety of municipal

Weighing a small red pine and intercepted snow. Socket into which the stem fits is directly below the hoisted tree.

watersheds is the use of light and radiant-energy relationships. To familiarize ourselves with these concepts and necessary instrumentation, a short-term study was undertaken at New Lisbon. The main objective of the study was to determine the relationships between a number of inexpensive instruments that might be used to measure light and radiant energy. A variety of instruments were exposed in the Lebanon State Forest under three cover conditions: pine, hardwood, and open. The study, which began in April 1964, will continue for 1 year, with measurements being taken from sunrise to sunset about 2 to 4 days each month.

The instruments used include a recording pyrheliograph (one only, for use in the open plot), economical radiometers, "poorman's" net radiometers with Goodell totalizers,, Gunn-



A variety of light, heat, and radiant-energy measuring instruments used in the New Lisbon study: (1) economical radiometer (black and white units), (2) Goodell net radiometer (black unit) with totalizer and battery, (3) Livingston black and white bulb altometers, (4) Brockway exposure meter (photocell), (5) set of three air thermometers, (6) set of three soil thermometers, (7) recording pyrheliograph (actinograph), and (8) Gunn-Bellani radiation integrator (pyranometer).

Bellani radiation integrators, black and white spherical Livingston atmometers, Brockway light meters, air thermometers, and soil thermometers.

Star performer was the economical radiometer, which deserves particular mention. Described by Swan, Federer, and Tanner (in Soils Bulletin No. 4, University of Wisconsin, 1961), the economical radiometer is an extremely versatile instrument capable of producing values from which the individual components of radiation may be determined: namely, incoming and outgoing solar, incoming and outgoing thermal (infrared), net solar, net all wave, albedo, and temperature of the surface over which the instrument is exposed. The net radiation absorbed by a forest stand is probably the value most closely related with the water use of that stand; it may be measured with no great difficulty by exposing these radiometers above the stand. Three economical radiometers were built on site without difficulty at a cost less than $100 each.

Weir Lining

Solar radiation, the source of our energy, is also the cause of one of our minor troubles. The black vinyl sheeting used to line our "poorman" weirs has begun to show signs of deterioration. The deterioration is caused by ultra-violet radiation, which catalyzes oxidation. The obvious solution was to construct simple wooden covers over the weirs. Byproduct benefits from the covers have been a smaller catch of leaves in the weir and less ice in winter.

Estimating Water Loss from the Streamside Area

A manuscript has been prepared that describes a method for estimating evapotranspiration from the riparian (streamside) zone of the Dilldown watershed. This zone always has a plentiful supply of soil moisture and may be expected to lose more water than the upland slopes where moisture deficits can occur during the growing season. Riparian water losses are graphically evident from summer diurnal fluctuations on the streamflow hydrograph. During warm, dry, daytime periods streamflow recedes and then recovers during the night. Although nighttime recovery does not always reach the true base-flow rate, a good measurement of base flow and water loss was obtained by connecting the two highest peaks of a series of diurnal fluctuations on the hydrograph. A sizable group of daily losses were determined in this manner and related to measured values of streamflow and vapor pressure deficit. Then an equation was derived from which these losses were estimated.

FLOODS AND WATER YIELD — NORTHERN APPALACHIANS

Parsons, W. Va.

In the previous annual report we described our "benchmark" watersheds that are being cut and treated with silvicides to eliminate as much vegetation as possible. On one of these, Fernow No. 7, the study has progressed far enough so that we can report some results.

This watershed was divided on the contour into an upper half and a lower half. Treatment on the upper half has been completed and analysis shows an increase in the 1964 growing-season streamflow of 82%, of almost 200,000 gallons per treated acre. Estimated increases for individual months, in thousands of gallons per treated acre, were:

May	None	August	45
June	53	September	39
July	34	October	29

In this study, desirable logging practices are being followed and damage to water quality from sediment has

Aerial view of Watershed No. 7 on the Fernow Experimental Forest after forest on the upper half was cut and a silvicide applied.

been slight. Also, water-quality tests demonstrated that there has been no detectable contamination of the water by the silvicide used.

As part of this experiment, the effect of forest removal on microclimate is also being studied. Preliminary analysis shows that sizable changes in summer air and soil temperatures have followed treatment. For example, the average range of July-August, maximum-minimum air temperatures at standard height (5.5 feet) increased 8°F. after cutting. Maximum and minimum 4-inch soil temperatures for the same 2 months averaged 10° and 4° higher, respectively, after treatment. Evaporation from Bellani blackplate atmometers was also increased. Studies like this, when expanded and intensified, will tell us how and why changes in streamflow followed treatment.

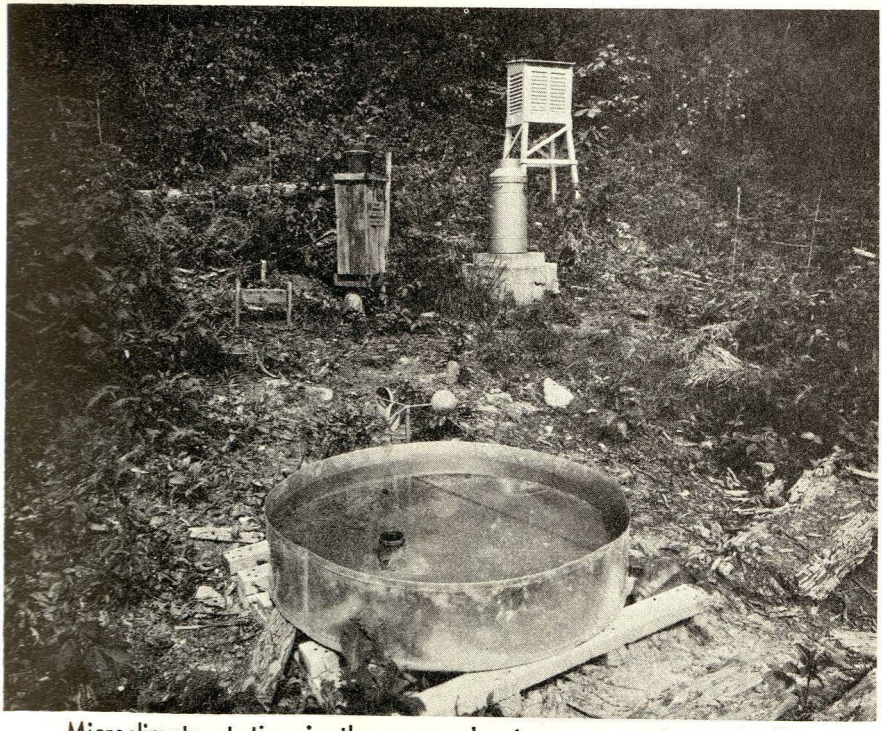
In a recently completed study a recording rain gage, modified to accommodate a section of live turf, was used to determine the general importance of dewfall in relation to our watershed-management studies. Total dew deposition in an open area adjacent to the Fernow Experimental Forest Headquarters for the May-November measurement period was 0.26 inch, or less than 1% of the 31 inches of precipitation received during the 7-month period. Because the error in precipitation measurements on most small experimental watersheds very likely exceeds 1%, the amount of dew at the Fernow location is probably not large enough to warrant being meas-

ured as part of our watershed-management studies.

An interesting technique for approximating soil-moisture storage in experimental watersheds was developed and reported on. Although direct measurements of storage are very difficult to take because of stoniness and wide variation from point to point, the new technique makes possible reliable approximations from comparisons of precipitation and streamflow amounts in selected periods.

A joint effort of the Parsons and Laconia projects was brought to a successful conclusion with the publication by the Government Printing Office of *Stream-gaging Stations for Research on Small Watersheds* (Agriculture Handbook No. 268). This publication covers the construction and operation of weirs and other types of gaging stations.

In other work, we are continuing to evaluate four different forest practices on streamflow. We are also working with an electronic data-processing program to relate estimates of streamflow based upon climatic data to discharge measured at our weirs. We have made a modest start in studying the effect of timber cutting on snowmelt and how this affects stream discharge. On two other watersheds, as former openland reverts to forest, streamflow is being measured to determine changes in hydrology that might result.



Microclimate station in the open, showing evaporation pan, anemometer, recording and non-recording precipitation gages, and instrument shelter.

FOREST INSECTS

THIS was a year of percussion and repercussion — a year in which unforeseen events created serious problems, later to be resolved.

The old laboratory at 335 Prospect Street, New Haven, was destroyed by fire in late March. By July 1 an option was taken on a 10-acre site in Hamden, Conn.; a site survey and plan were completed; design criteria were prepared for a new laboratory; and money was allotted for architectural and engineering planning. Some experiments were negated by the fire; other, more critical experiments were carried on in space generously provided by the Connecticut Agricultural Experiment Station and Yale University. Suitable office and laboratory space was found nearby in West Haven (135 Wood Street), and the staff and all recoverable material were moved to this address in early June. Some records of past research were lost, but these had lain fallow for a considerable time and probably would have remained so. Some treasured but rather decrepit office and laboratory furniture was consumed by the fire or inundated; however, the scientific equipment and supplies came through nearly unscathed. Some insects in rearing were destroyed; the insect collection and library material were only smudged.

Having barely recovered from this, we were shocked to receive a significant increase in program funds with the admonition to probe more deeply into the biologies of the major pests and to accelerate our research on biotic methods of control. And further encouragement was given to the idea of developing a new line project to grapple with the problems of defining and assessing the impact of destructive insects on Northeastern forests.

The Divisions of Forest Insect Research and Forest Disease Research were merged officially on July 1, and the legitimacy of their common goals in forest protection and their biological involvements was thus established.

A resumé of research accomplishments in 1964 follows.

INSECT BIOLOGY

The dispersion of an insect — the efficiency of its host-finding movements — is a critical element in survival. Dispersion is particularly important when an insect has two hosts that each provide food and shelter for specific stages of the insect. The pine leaf aphid has evolved host-finding mechanisms that give it a high probability of success in reaching white pine and spruce in turn. Because the injury inflicted to white pine is the more serious, and because this tree species is more valuable generally, our initial study of pine leaf aphid dispersal is concentrated on the movement from spruce to pine.

Direct observations in the field indicate that light quality is an important factor in the aphid's dispersive behavior. Upon leaving its gall abode on spruce, the migrating form — which is strongly photopositive — rises in a curious spiral toward the sky. It is then captured by the wind and carried more or less inertly for a variable dis-

tance. A visual stimulus brings the insect to white pine — and trapping and foliage sampling indicate that it rarely alights on other tree species.

A special wind tunnel was designed and constructed to study in some detail the aphid's manner and speed of flight, fall rate, physiological flight capacity, and response to different wave lengths of light.

Our population studies of the gypsy moth exemplify the range of data and analyses needed to gain insight and some answers to key questions. Analyses have been made of a 21-year record of abundance in 264 plots in eastern Massachusetts and adjoining sections of Maine and New Hampshire, and of more detailed intrageneration data over a 6-year period from 13 sites in eastern New York. The latter were tabulated in the form of life tables.

In brief, the 21-year record revealed an interesting synchrony of population change in all plots, with all having a predictable pattern of change in this time span. The life-table data, dissected and analyzed through a series of mathematical models, yielded the following sequence of information: (1) variation in adult sex ratio appeared to be an important determinant of population trend from year to year; (2) the sex ratio or proportion of females, however, was determined largely by mortality-causing agents operating on the large larvae and pupae; (3) the primary agent that affected male and female larvae differentially was disease, while disease and ichneumonid parasites determined the relative probabilities of survival of the pupae; and (4) the incidence of disease and ichneumonids in turn were directly correlated with population density of the insect. When the gypsy moth populations were segregated into two density strata, evidently this particular sequence of factors was applicable only to the more dense populations.

At sparse levels, disease and parasite effects were negligible, and the loss of small larvae through dispersion and the predation of large larvae were the primary determinants of population trend.

Thus it appears that the most efficient means of controlling increasingly dense populations of the gypsy moth may be through a manipulation of the environment that will increase the incidence of natural disease, or by the introduction of a supplementary disease agent into the population. And the prevention of increase from endemic levels may be achieved by maintaining conditions that favor predation (by birds and small mammals, particularly), or possibly by use of sterilized or otherwise genetically altered male gypsy moths to sow the seed of their own destruction.

The results of the 1963 release of gamma-irradiated male gypsy moths were very promising, but not conclusive. The majority of egg masses collected in the experimental area produced no progeny in 1964, but some eggs did hatch successfully and the average percentage hatched for the various irradiated-male dilutions was higher than expected. We concluded that the ratios of treated to normal males were not high enough to insure maximal reduction, and that the irradiation treatment did not sterilize all of the males completely and/or the treated males were not fully competitive with the normal male moths. This study is continuing.

The investigation of the preference for and aversion to different tree species by the gypsy moth was necessarily modified this year. Various components of leaves of red oak (a preferred host), poplar (an acceptable host), red maple (a species rarely fed upon), and ash (a species never fed upon) were presented to instar II and III gypsy moth larvae in various forms — utilizing a neutral cellulose-agar carrier in most cases. A fecal pellet

count was used as the measure of food intake. The results in the laboratory did not duplicate the field experience: even the ash was fed upon. This indicates that the ash contains a strong repellent or feeding inhibitor that is altered or nullified when the foliage is removed from the tree — another example of the difficulty in making laboratory tests of insect behavior valid and meaningful.

More details of the life history and behavior of the anthocorid predator of red-pine scale were obtained this year, and it was identified positively as *Elatophilus inimica.* In a wide-ranging search, the predator was found on red pine at locations in northern New Jersey, southern New York, and Connecticut where the scale was present. It was also found on pitch pine on Cape Cod where another *Matsucoccus* species occurred. Intensive sampling of field plot populations has shown that the intermediate stage of the red-pine scale is very susceptible to predation by the anthocorid, and analyses of the data indicate that any marked reduction in this stage has a significant effect on the population level of the scale in the next generation.

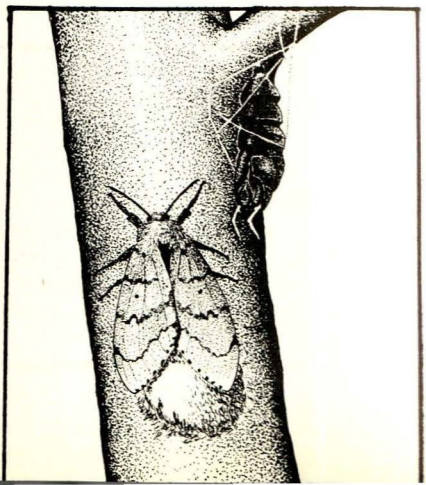
BIOTIC CONTROL

The investigation of the microbial insecticide *Bacillus thuringiensis* as a control agent for the gypsy moth and other forest defoliators was confined to the laboratory this year. A difficult problem was solved when the components that had limited the effectiveness of a newly developed liquid were discovered and subsequently removed from the production material. In laboratory tests with the gypsy moth, the improved liquid formulation was demonstrably more toxic than previous preparations. A new powder formulation of *Bt,* produced by another manufacturer, was shown to be very potent also.

In more detailed tests, separate components of *Bt* were fed to gypsy moth larvae in graded dosages. Pure spores effected mortality at concentrations of about 10 million to 10 billion (viable) per milliliter. The crystal toxin, dissolved and reprecipitated, killed young larvae over a wide range of concentrations. And a crude extract of the heat-stable exotoxin also proved lethal, with the killing action augmented by the inhibition of molting.

Studies of the natural microflora of the gypsy moth (conducted in cooperation with the Bacteriology Department of the University of Connecticut) have shown clearly that insect pathology, like human pathology, is not a simple affair. For example, a slime-producing *Proteus,* isolated from gypsy moth larvae collected in 1963 and 1964 over a wide area, was held suspect as the cause of a disease condition which, for want of a better name, was termed "desiccation." The slime material produced by this bacterium was shown to have a high water-binding capacity. Feeding tests, however, produced no direct disease effect. The desiccated condition appeared in the untreated, as well as in the treated, lots of gypsy moth larvae. An association was indicated, though, by a sig-

A female gypsy moth laying her complement of eggs.



nificantly higher incidence of the disease in the treated group. We are now trying to unravel the puzzle.

Disease bank activities were continued. Fresh polyhedral virus suspensions were prepared from diseased specimens of European pine sawfly, forest tent caterpillar, linden looper, fall webworm, and gypsy moth. For control purposes, disbursements were made of the sawfly and tent caterpillar viruses.

CHEMICAL CONTROL

Various thin-layer chromatography techniques were tested for efficiency in detecting certain systemic insecticides in white pine. First used were candidate chemicals for controlling the white-pine cone beetle. A solvent system of butanol, acetic acid, and acetone was found to carry Bidrin, Zectran, Bayer 39007, and Bayer 29493 sufficiently well to allow separation of these materials in laboratory-prepared extracts of young white pine cones. A reagent schedule of bromine fumes, fluorescein, and silver nitrate made the insecticide spots clearly visible.

From field and laboratory evidence of toxicity to the cone beetle and its capability for translocation in white pine, Bidrin again was selected for field testing against this increasingly serious pest. Various methods of introducing the material into trees of different sizes, and different combinations of toxicant concentration and quantity of liquid were tested, with somewhat erratic results. We can say, however, that a significant proportion of the cone crop on a tree can be protected to maturity by using this systemic insecticide.

Several series of screening tests were conducted with new insecticidal chemicals against young gypsy moth larvae. Dipped oak foliage and an artificial diet medium were used, with DDT serving as the standard in all tests. The most significant results were obtained with the artificial medium, where Zectran and an experimental Mobil Chemical Company material gave much higher kill than DDT at equal concentrations. The search for safer, nonpersistent chemicals for controlling the gypsy moth and other defoliators will continue.

INSECT IMPACT

The guideline for evaluating and scheduling white-pine weevil control in the Northeast was put to test this year. The Forest Pest Control Branch, R-7, conducted a pilot test, utilizing 30 white pine plantations distributed throughout the Northeastern States, according to a plan designed by Station personnel. In brief, the working tables in the guideline provided predictions of the proportion of never-weeviled trees to be expected in 1, 2, and 3 years with a higher degree of success than specified by the confidence levels of the plan; at least this held true in the plantings from Pennsylvania northward, where the original data were obtained. In Virginia, the predictions fell short of the goals set.

With the predicted rate of decline in never-weeviled trees, estimated growth rate of these trees, and assumed management objectives of rotation age, number of crop trees per acre, log length, and minimum acceptable rate of return on weevil control, realistic decisions on if and when to apply weevil control were made for the test plantations in Pennsylvania, New York, and New England. We now have a prototype of the sort of control guideline needed by forest managers for decision-making on *all* destructive agents.

Additional data were obtained by the R-7 crews and State cooperators to improve the methods of sampling involved in using the guideline and to extend its application to natural white pine stands.

FOREST DISEASES

ON the basis of a searching review of forest-disease problems in the Northeast and an evaluation of the scope and intensity of research needed to provide answers, the Station's disease-research program has been re-oriented along two major lines: (1) diebacks-declines and wilts, foliage diseases, and root diseases, and (2) decays and discolorations. Problem analyses are being prepared to define these subject-matter areas and to establish criteria for selecting, scheduling, and organizing the studies most warranted.

The burning of the old laboratory in New Haven drastically curtailed research in forest diseases. However, the current program has been trimmed and sharpened both to maintain headway with lessened facilities and a smaller staff and to meet the challenge of the new program. A summary of our progress in 1964 follows.

DIEBACKS AND DECLINES

The symptomatic conditions of trees that fall within this broad category reflect the very complex interactions of the physical environment and the biotic factors that affect tree growth. Disease-causing microorganisms, of all degrees of pathogenicity, are a key element in this picture.

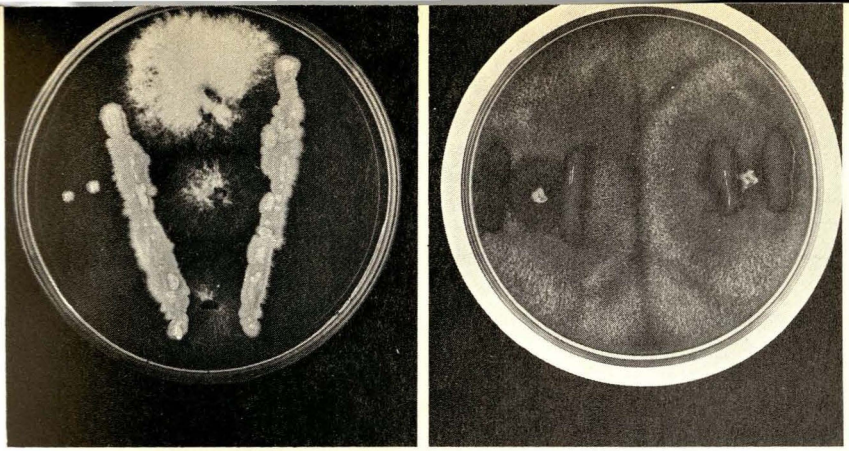
But full understanding of the disease complex, and the development of means to break the skein effectively and to minimize the losses in forest productivity and value caused by these microorganisms, requires radical probing into tree physiology, meteorology, soil-water relations, insect biology, and other fields — to the extent needed to discern their role. Experience elsewhere with oak wilt and maple blight has made it very clear that concentration of research on the fungal and other microbial pathogens alone provides incomplete answers at best. This is an area in which the integrated approach is a prime necessity.

The extreme drought in most parts of the Northeast this year, coupled with increased fungal and insect activity, brought on a full gamut of dieback and decline conditions that culminated in the mortality of hardwoods in many areas. All this gives ample opportunity indeed for research.

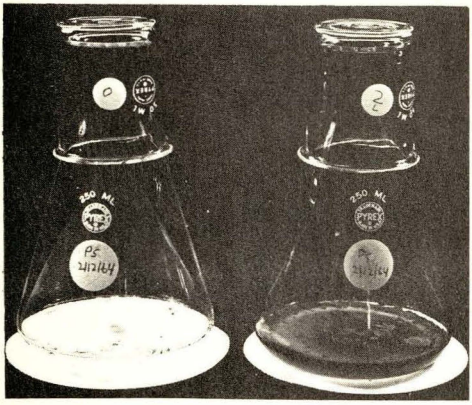
ROOT DISEASES

This year we made our final examination of study plots established to test the effectiveness of stump treatments and thinning by poisoning in reducing initial invasion of stands by *Fomes annosus*. Under the test conditions in New England, infection of creosoted red pine stumps and trees poisoned with sodium arsenite was significantly less than the infection of untreated stumps. In Maryland, poisoning standing loblolly pines with 2,4,5-T was not effective in preventing infection, and indeed may have increased it. Three years after application, creosote reduced infection when compared with no treatment, but was much less effective than urea.

In addition, trials were run to determine the effectiveness of soil fumigation in killing *F. annosus* in roots variously decayed. Preliminary analyses

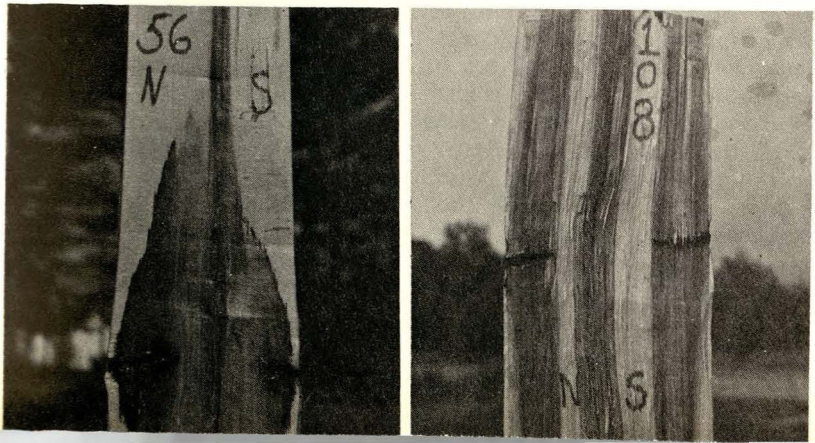


In the plate to the left, growth of the decay fungus ***Fomes igniarius*** is limited in culture by bacteria streaked on either side of it. In the plate to the right, ***Cytospora decipiens***, a discoloration fungus, is not limited in culture by bacteria intimately associated with it in living trees.



Phialophora melinii growing in a liquid medium; the same medium is used in each flask except for the addition of a trace of manganese in the flask on the right. Pigmentation in other fungi also was affected by manganese.

The discoloration pattern on the left is typical of that that follows increment boring in red maple. The fungi isolated from these tissues were the same as those isolated from discolorations that followed logging wounds. The discoloration pattern on the right developed in yellow birch after boring.



indicate that, under the test conditions, the fumigants (methyl bromide and Vapam) both markedly reduced *F. annosus* in the roots; but methyl bromide appeared more effective than Vapam.

BASAL CANKER OF WHITE PINE

Studies have been under way since 1961 to determine the cause and manner of development of a basal canker of white pine that is responsible for serious losses in young plantations in the Tug Hill region of north-central New York. We now know that the cankers are initiated by ants, primarily *Formica fusca,* and also by snow and ice damage to lower branches and the tree base. Field observations and greenhouse trials have demonstrated that the ants alone can kill small, young trees. In these trees, and in others not killed directly, dead tissues in and around the ant wounds and damaged limbs were colonized by fungi. Inoculation tests showed that certain of these fungi were pathogenic. For example, one of these fungi (as yet not identified) girdled and killed 8-year-old seedlings in one year. In many cases, death of larger trees was hastened when mice fed around the cankered section and completed the girdling action.

DECAYS & DISCOLORATIONS

Recent studies have indicated clearly that decays and discolorations of northern hardwoods are complex phenomena that often involve intimate interactions of several different kinds of organisms with the host tree. Our current research is designed to clarify the interrelationships of the components involved.

In one study, trees decayed by *Fomes igniarius, Poria obliqua,* or *Polyporus glomeratus* were cut, dissected, and and examined. The principal fungi associated with the discolorations and with the decay were *Phialophora melinii, Trichocladium canadense, Cytospora decipiens,* and *Hypoxylon* spp. Bacteria were associated closely with both the decay and discoloring fungi. The principal bacteria were identified tentatively by bacteriologists at the University of Connecticut in connection with a cooperative research project. Their findings to date indicate that although many different species of bacteria are present generally only a few are isolated frequently from all trees. The primary bacterium is thought to be a previously undescribed species of *Erwinia,* a genus containing many known plant pathogens. An extension of the cooperative project with the University of Connecticut is aimed to characterize the physiology and biochemical reactions of the most important of these bacteria.

Our cultural studies have revealed that bacteria may influence greatly the growth and behavior of the fungi associated with them in living trees. For example, the bacteria isolated from discolorations around decay columns inhibited the growth of the decay fungus *F. igniarius,* but not of the discoloring fungi. Also, pigment formation by *F. igniarius* was stimulated by the presence of a bacterium.

Pigmentation by several discoloring and decay fungi was influenced also by microelement concentration of the growth medium. Pigmentation by *P. melinii* and *C. decipiens,* for example, was affected by minute changes in manganese concentration.

In another study, a sample was taken of trees bearing variously-treated increment-borer wounds. Regardless of treatment, the fungi cultured from the discolorations around the borer holes were the same as those found in the above studies. Exceptions were species of *Graphium* and *Fusarium* isolated from unplugged holes. These fungi commonly are carried by insects. The discoloration that followed boring was much more extensive in yellow birch than in red maple.

FOREST PRODUCTS MARKETING

RECOGNITION of the need for research to improve markets for forest products seems to be growing by leaps and bounds. Innumerable articles in trade journals, speeches by wood-industry people, and conference reports point out the critical need for research aimed at improving markets for wood products. Our Forest Products Marketing Laboratory at Princeton, W. Va., is fortunate in having been established early enough to be ready to contribute to this fundamental element of the forest industry.

The exceptionally favorable climate for marketing research has helped the Laboratory to make good progress during the past year. We have made some false starts, gone down a few blind alleys, but, in general, have made considerable progress. A total of 23 studies were in some stage of planning or execution at the end of 1964. Six manuscripts were published during the year, another six were submitted for publication, and nine more are in preparation. At year end the Laboratory staff was composed of 10 scientists and 13 supporting people. Recruiting is in progress for scientists to fill two vacancies.

The Laboratory's well-equipped meeting and conference facilities have brought a number of organizations to Princeton. Many people come to the Laboratory for help on marketing problems. The volume of direct mail requests for information — both from the U. S. and overseas — is growing rapidly. And the number of referrals from other Forest Service units is also increasing. We also are called on frequently by local, State, and Federal agencies for technical advice on establishing new wood-using industries. These activities, although not really research accomplishments, constitute a badly needed service. They also enable Laboratory personnel to maintain a better understanding of industry problems.

Brief summaries of several studies that were completed during the year or have advanced to the point of providing preliminary results are presented in the following pages.

PRIMARY FOREST PRODUCTS

Log Grading as a Marketing Tool

During the past year, the Laboratory conducted a study to determine the actual cost of grading hardwood sawlogs in the Appalachian area and to determine and assess the relative importance of factors that affect grading costs. Scaling costs were also investigated because scaling and grading are normally performed as a joint operation. Partial analyses of the results show the following:

1. A one-man scaling and grading crew is more efficient than a two-man crew regardless of log size or whether the grading is done at the stump, woods landing, sawmill yard, or sawmill deck.

2. An efficient man can scale and grade between 25,000 and 30,000 board feet of logs per 8-hour day. Production depends partially upon the cooperation received from other members of the logging and sawmilling crews.
3. Log grading requires considerably less time than scaling. Because logs are measured and evaluated for defects in the scaling process, part of the grading procedure is already accomplished.
4. Preliminary data indicate total cost for scaling and grading should be less than $1 per 1,000 board feet with a daily production of 30,000 board feet. Grading alone probably amounts to approximately 20% of the total cost or about 20¢ per 1,000 board feet.
5. Log grading can be done more efficiently at the mill yard or the sawmill deck than at the stump or at the woods landing. However, there may be occasions when a small added cost is justifiable in order to separate logs at the stump or landing for marketing purposes.

Forest Cooperatives

Over 70 forest cooperatives have been established in the U. S. during the past 50 years. Only 16 remain today, and most of these are of recent origin. Why were these cooperatives formed? How did they operate? What did they accomplish? Why did most of them go out of business? And what are the social and economic factors that control the success of forest cooperatives?

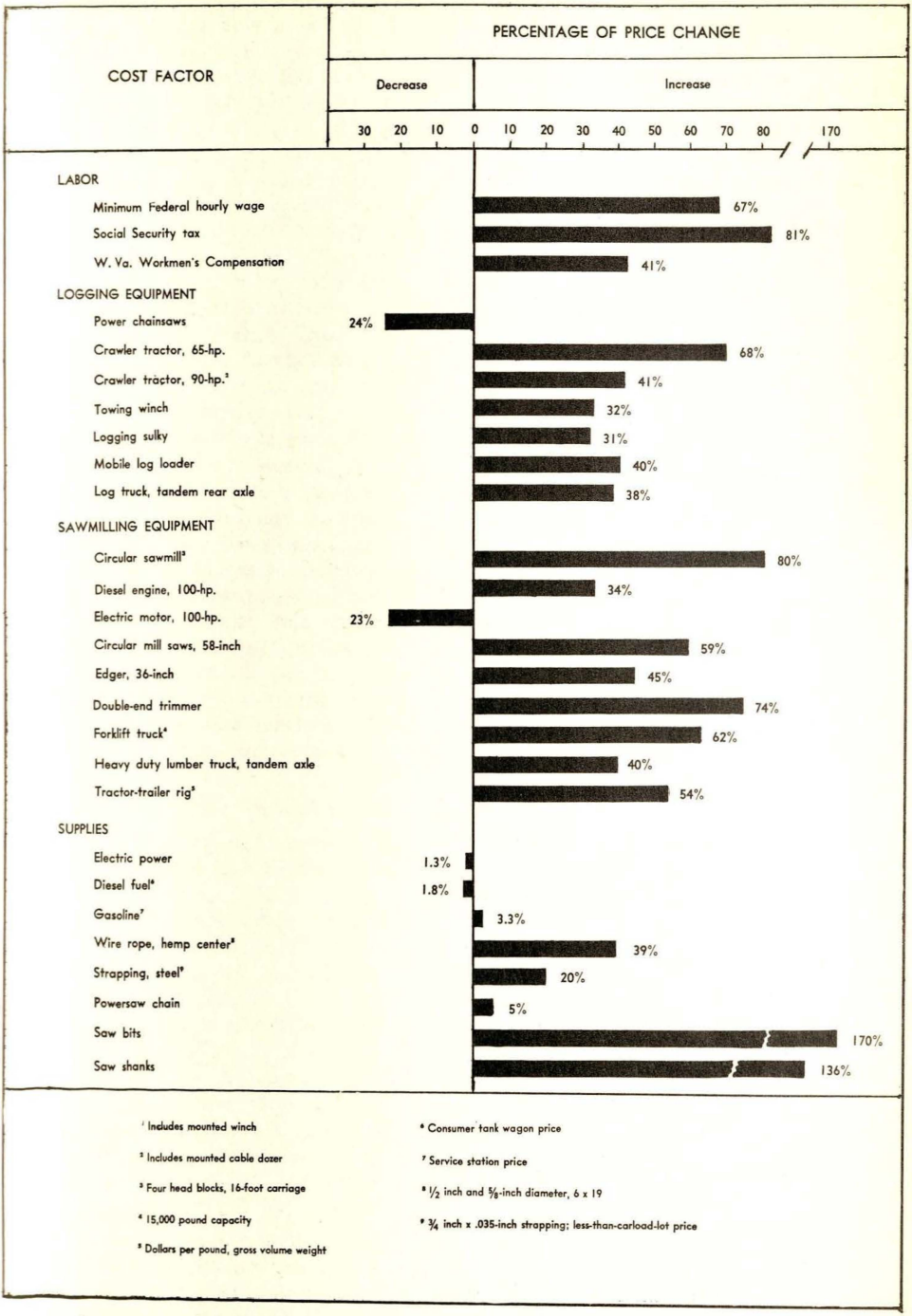
Research at the Laboratory has shown that a number of factors were responsible for closing most of these cooperatives. Many failed because inadequate management effort was expended to insure efficient and successful operation. Other cooperatives were dissolved because they had fulfilled the purposes for which they were organized. The dissolution of others has been attributed to insufficient justification for initial establishment: There may have been a social need for them but apparently there was no economic need. Results will be published at an early date.

PRIMARY WOOD PRODUCT MANUFACTURES

The major research efforts during the year in the area of primary wood product manufactures were concentrated on problems related to the marketing of sawmill products. The hardwood lumber industry is experiencing an extended period of strong volume markets; yet a relatively level lumber price structure, coupled with increasing production and marketing costs, is resulting in narrow profit margins. Therefore studies have been aimed at potential areas for improved efficiencies in the conversion-marketing chain in an effort to help strengthen the profit margin in the industry. Price increases for lumber would serve the same purpose but could further weaken the competitive position of lumber as a raw material for remanufacture.

Changes in Logging and Sawmilling Costs

Logging and sawmilling costs are climbing. An analysis of 27 of the principal logging and sawmilling production cost factors shows that prices for 23 of the selected items have increased from 3 to 170% over the past decade (1954-64). And the other four items decreased from 1 to 24% over the same period. The analysis showed that capital expenditures to purchase equipment necessary for a typical small to medium-size logging or sawmilling operation rose from 45 to 50% during the 10-year period. Apparently, however, cost increases for some



Percentage of price change of logging and sawmilling cost factors, 1954 to 1964.

items of equipment and supplies are at least partially offset by corresponding increases in productive capacity and service life, or less maintenance and repair requirements.

Trends in Lumber Recovery Values

Lumber production costs have risen steadily over the past 10 years. During this same period, however, lumber recovery values for Appalachian hardwoods have remained fairly stable. The three major hardwood species groups harvested in the region — red oak, white oak, and yellow poplar, which represented as much as two-thirds of volume harvested in States like West Virginia — registered a composite increase in only 1.09% or $1.36 per 1,000 board feet over the entire 10-year period. This amounted to an average increase of only 14¢ per 1,000 board feet per year over the last decade. Altnough the predominant species harvested exhibited very little increase in lumber recovery value, there were some exceptions. Both black cherry and soft maple showed substantial increases of $14.80 and $26.07, respectively, for log grade 1 over the period. However, these species represent only a small proportion of the total volume harvested in the region.

Because of the rising production costs involved in manufacturing hardwood lumber and the relatively stable trends in lumber recovery values, it is not difficult to understand why most lumber producers in the region are experiencing a declining margin between operating costs and income. Sawmill owners and operators must now become more cost conscious by developing a better understanding of their individual cost-profit situations.

Evaluation of Factory Grade 3 Sawlogs

Recent Forest Survey data for West Virginia, Kentucky, Pennsylvania, and other Appalachian states indicate that hardwood sawlog growth is considerably greater than the current rate of cutting. But the reports also show that approximately 70 to 75% of sawtimber volume is in factory-grade 3 and tie and timber grade logs. A study was carried out during the past year to determine the minimum size of grade 3 hardwood sawlogs that can be sawed profitably at efficient sawmills. Production rates, production costs, and product values were determined for grade 3 red oak, sugar maple, and yellow-poplar logs of different diameters at the three major types of sawmills in the region — circular, band, and band with resaw equipment.

Preliminary results indicate that on the basis of current sawlog values, red oak and sugar maple logs 12 inches and larger in diameter can be processed profitably at the better sawmills, and that factory-grade 3 yellow-poplar 11 inches and larger in diameter are profitable. The final published analysis will provide information on the rate of return from sawing grade 3 logs in each diameter class at each of the three types of sawmill units.

Evaluation of Air-drying Practices

A study of air-drying practices in the Appalachian area involved dual grading of 329,000 board feet of air-dry oak and poplar lumber at 17 sawmills and concentration yards in five central Appalachian States. Results of the study indicate that careful application of presently known air-drying practices will result in well-dried lumber with little seasoning degrade. However, when proper care is not exercised, seasoning degrade can result in poorly dried, degraded lumber that loses money for the producer and is poor raw material for the consumer.

Preliminary analyses show that seasoning degrade in yellow-poplar was insignificant, but that the average degrade loss in air-drying red oak in the Appalachian hardwood region was

more than $10 per 1,000 board feet. The losses in drying red oak ranged from a few cents to more than $100 per 1,000 board feet. However, more than half the mills had degrade losses of less than $2 per 1,000 board feet. The major types of seasoning defects were split and check. The major causes for degrade were lack of proper stack roofing and the use of an inadequate number of stickers in the stacks. No correlation was found between size of mill or yard and the magnitude of degrade losses.

Lumber Preferences by Industrial Users

A study to determine the hardwood lumber user preference by the flooring, furniture, and pallet industries is nearing completion. The purpose is to determine what these users need in hardwood lumber products to provide a basis on which to recommend changes that will better meet the needs of manufacturers in these industries. Benefits to users should accrue in greater utility and cost savings. Producers should also benefit in achieving strengthened markets and possibly price increases for their lumber.

Preliminary analysis of the data obtained from interviews with company officials in the oak-flooring industry indicates that about two-thirds of the companies would save operational time and money if all lumber shipments met their preferred specifications. Company officials thought that it would result in lower handling costs, savings in labor costs, reduced lumber waste, and increased flooring yields. More than one-half of the officials indicated that their companies would be willing to pay $2 to $8 more per 1,000 board feet for hardwood lumber manufactured and delivered according to their preferred specifications.

Lumber specifications that appear to be most desired by the majority of flooring manufacturers called for rough, red oak lumber of No. 2 and 3A common grades. Lumber should be uniform in dimension and not less than 1⅛ inches thick if green and full 4/4 inch if air dry. Air-dry material should have 20 to 25% moisture content. Length may be random, but widths of 3, 6, 9, and 12 inches are preferred. Lumber should be separated, packaged, and shipped by species and lengths on trucks or chain-cars suitable for forklift unloading. Prompt delivery in accordance with contract schedules is of great importance to the purchasers.

SECONDARY WOOD PRODUCT MANUFACTURES

Research in secondary wood product manufactures has been concentrated on the wood flooring and wood pallet markets. Data collection was completed during the year for a study to determine the factors that affect the use of wood flooring on slab-type construction. The study is being conducted by the Washington Office of the Forest Service in cooperation with the Princeton Laboratory. Results will be available by early summer. Preliminary results of two studies under way at Princeton are as follows:

Comparative Maintenance Costs of Residential Floors

Data for the Boston segment of the study of comparative maintenance for residential floors was collected and analyzed during the year. It is the first of nine large metropolitan areas from Boston to Los Angeles to be covered in the study. The Boston results showed that housewives spend about one-fourth less time caring for hardwood strip flooring than for an equal area of wall-to-wall carpeting, one leading competitor of hardwood flooring. On an annual basis, the difference in day-to-day care of an average 12- by 18-foot living

room would amount to over 12 hours advantage in favor of wood.

The Boston data also indicated that household maintenance of oak strip flooring required about one-half the expenditure for cleaning materials such as wax, cleaner, shampoo, and similar expendable items as for wall-to-wall carpeting. In addition, the cost of professional services for commercial carpet cleaning was three times greater for wall-to-wall carpeting than the cost of similar services, such as sanding and refinishing, for oak strip flooring.

Total maintenance costs for expendable materials used by the housewife for oak strip flooring, plus professional care, amounted to only 40% of the cost reported for wall-to-wall carpeting. This difference in annual or long-term costs is even more dramatic when one realizes that, because of the difference in wear life of the two materials, carpeting is usually replaced at least three times as often as oak strip flooring.

These differences in maintenance costs may be partially responsible for the preferences expressed for hardwood flooring over other flooring materials in new homes. Over 50% of the Boston housewives who returned questionnaires specified that they preferred some type of hardwood flooring in the living room and bedrooms of a new home. This compares with only 33% of the respondents that preferred wall-to-wall carpeting.

Problem Analysis of the Wood-pallet Industry

A problem analysis of the manufacture, marketing, and use of wood pallets was prepared during 1964. The analysis showed that the wood-pallet market has great economic importance because it provides a large market for the lower grades of hardwod lumber that are becoming increasingly more abundant throughout the Appalachian area. Approximately 16% of all hardwood lumber production and 2% of all softwood lumber production in the U. S. goes into wood pallets. This amounts to about 5% of the total U. S. lumber production. About 66% of all wood pallets are made of hardwood lumber.

The wood-pallet industry has had a rapid rate of growth during the last 20 years and at present has a comparatively favorable market position in the materials handling field. Over 71.5 million pallets were produced in 1963 — about three times greater than the 1950 production. Nevertheless, the analysis shows that the market position of wood pallets may be in danger from competitive materials because of economic and technical problems associated with wood pallets as well as a result of the superior research and merchandising activities employed by competitors.

The analysis shows a pressing need for large-scale tests to determine the utility of pallets of different types under actual service conditions. A need is also apparent for evaluating the opportunities and values of wood pallet handling systems in different industries. There is also a need to develop measures that would lead to greater uniformity of quality in pallets sold to industry, to develop better methods of merchandising, and to improve the system of procuring hardwood lumber used in pallet manufacture.

WOOD IN CONSTRUCTION

A study of the opportunities for increasing the use of treated hardwood guardrail posts in highway construction has been completed. We found that approximately 25,000 to 30,000 highway guardrail posts are used annually in new highway construction in West Virginia alone. Hundreds of thousands more are used each year in other nearby States. Highway bid invitations in West Virginia allow con-

tractors to choose between treated wood, steel, or concrete posts for guardrail installations. An abundance of suitable wood material is available for treated wood posts; yet in recent years steel posts have been used almost exclusively for guardrail installations in the State.

Data supplied by the principal contractors of guardrail posts in the State showed that the average material costs per post ranged from $2.50 for treated wood to $5.68 for galvanized steel. Thus, wooden posts were initially much less costly than other types of posts. And when all cost factors were taken into account, the in-place cost of wooden guardrail posts was $0.74 less than its nearest competitor. One new corporation has been formed on the basis of these results and has been successful in bidding for the installation of wood material.

UTILIZATION IMPROVEMENT

THE year 1964 has been a good one for most of the Northeastern lumber industry. All segments of the industry have experienced satisfactory to excellent economic conditions. Although there was a trend toward price increases, general operating costs also rose.

The year saw the installation of several new medium-size sawmills in the region and a considerable increase in pulp and paper production. The sale of sawmill residues to the pulp and paper industry continued to provide additional profits from previously worthless residues. The installation of chippers or the sale of sawmill residues to chipping centers continues to contribute to the progress of the sawmill industry in the area. The use and production of particle board continued to expand, and the market remained very firm for this type of material.

TIMBER HARVESTING

The continuing demand for a variety of products from each harvesting operation still results in multiple sales based on log quality and log grade. Grading continued to gain acceptance, although no standard methods prevail.

In view of the multiple-product type of sales developing on harvesting operations, loggers continually are interested in the economics of their operations, and considerable work has been done on cost accounting approaches to the harvesting operations. Data presented at the Northeastern Logger's Congress should help as guidelines for many operations within the area.

The purchasing of hardwood pulpwood by weight continued to be increasingly acceptable to many companies during 1964, and the initial

difficulties in dealing with suppliers have generally been overcome.

SAWMILLING AND GRADING

The use of both hardwood and softwood residues from sawmills in the form of chips has become an established practice of the sawmilling industry in the Northeastern region. The development of concentration centers for chipping procedures and the method of transporting chips in the area were of such interest to other parts of the country that we were asked to summarize this information for a national conference. Now several areas are developing patterns similar to those in the Northeast.

Several mill-scale studies to determine the recovery from graded logs were conducted in conjunction with the national hardwood log grade project and Region 7. A series of red oak studies that involved 681 logs was carried through to the final air-dry grading stage. Red maple log-grade studies and a scarlet oak mill-scale study were carried out and the data are being processed to permit revision of an existing publication.

SEASONING

We continued to be active with organizations interested in dissemination of seasoning research. The staff were called upon to give several lectures on specific seasoning problems and the various aspects of up-to-date research on these problems. A survey of the Northeastern area with the leader of the national seasoning program from the Forest Products Laboratory indicated that there are several important research programs that should be carried out in the seasoning area. We are working with one of the Universities in the Northeast in a cooperative effort to accumulate and publish up-to-date information involving drying of frozen wood. We expect that cooperative aid research will develop from this informal project.

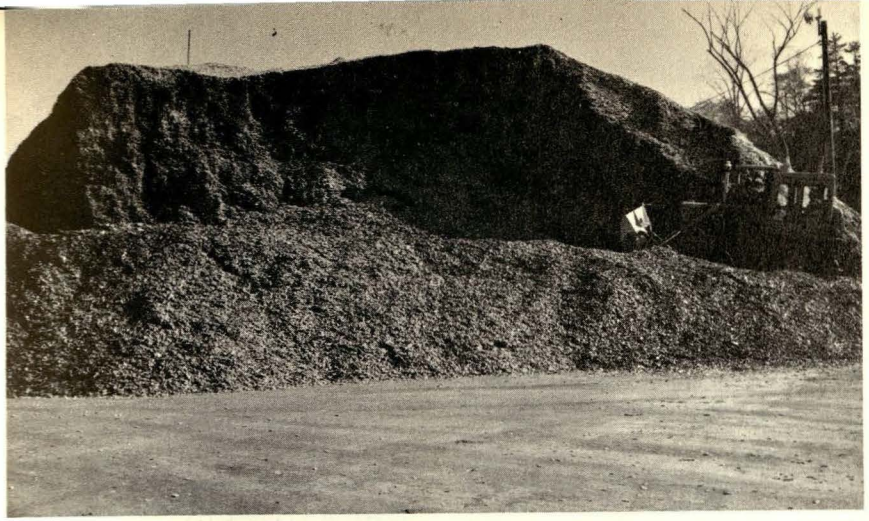
It was impossible during the past year to carry out any research projects in high-frequency drying because of other personnel committments. A cooperative project with users and manufactures of high-frequency equipment is planned for the coming year to define the capabilities of existing equipment, and to investigate the costs of operation in successful installations.

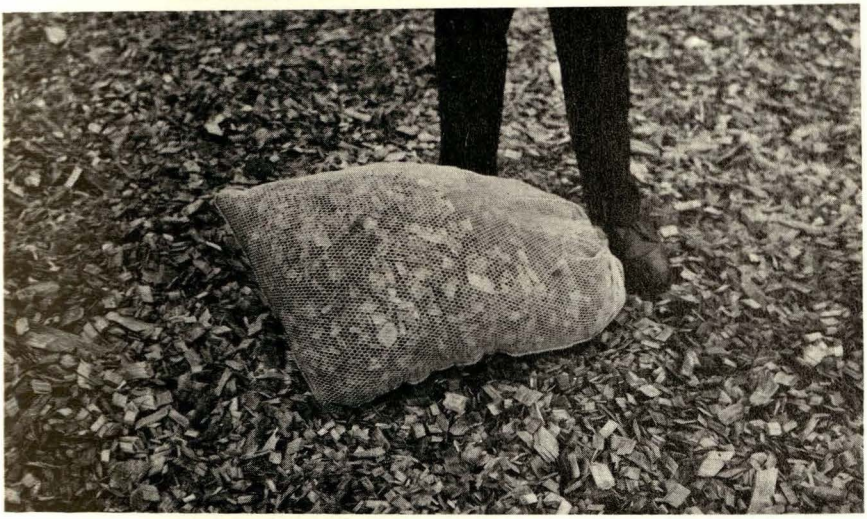
Because the national seasoning program at the Forest Products Laboratory calls for a discontinuance of the Laboratory's kiln drying demonstration within the next few years, the Division is cooperating with interested parties to develop a kiln-operator's training program of comparable value somewhere in the Northeast for the benefit of the entire seasoning industry.

PULP AND PAPER

Preliminary investigations reported last year indicated that there were some problems peculiar to the outdoor storage of Northern hardwood chips for the production of pulp and paper which were different from those reported on the outdoor storage of other chip species. In an effort to determine some of these conditions, a cooperative project was developed between the Forest Products Laboratory, a large paper company in the Northeast, and the Northeastern Forest Experiment Station.

To study the effects of outdoor exposure on chips, more than 3 tons of northern hardwood chip samples in nylon bags were deposited in a large storage pile of similar chips in May 1964; some of these bags were then removed each month. Removal of the samples was completed in November 1964, and analyses of the data have begun.





Face of northern hardwood chip pile as exposed in cutting out sample bags like the one shown below. Dark streaks at top of the pile are water-soaked chips.

The Division of Chemistry, Forest Products Laboratory, is analyzing chemical changes in the wood of the samples. The paper company will process the samples into pulp and will make standard tests of the pulp in its laboratories; and the Northeastern Station will report on the existing pile conditions during the tests — as recorded by thermocouples, gas measurements, and exterior weather condition measurements.

Certain chip samples were chemically treated to prevent deterioration. Upon removal, these chips appeared to be in better condition than any other samples. And if some method can be developed to remove the chemicals during the pulping process, this type of treatment could be outstandingly successful in preventing deterioration.

OTHER WOOD-USE DEVELOPMENTS

The final paper of the Northeastern Forest Experiment Station series on beech utilization was published last year and a cooperative agreement has been signed with a university to reprint this series in a single volume. Publication is expected before the end of 1966.

The National Institutes of Health asked us to investigate the use of wood particles for experimental animal bedding. We prepared a series of specification suggestions which were adopted in part by NIH; and when the specifications were issued for bid a supplier in the Northeast was the successful bidder. NIH previously experienced considerable difficulty in finding suppliers for sawdust to meet their specifications. They are now operating without difficulty.

As an adjunct to this specifications work, division personnel have been asked to investigate and to work on the development of specifications for wood flour as a part of the work of the American Society for Testing and Materials.

And in conjunction with several other agencies within the state, we worked with a local treating plant to rehabilitate completely its processes and operations so that it could continue in business. The rehabilitation has proved successful and the plant has supplied large amounts of fireproof wood for New York City construction and particularly for the World's Fair buildings, in addition to its other production.

OTHER ACTIVITIES

Division personnel continued to be active in affairs of the Forest Products Research Society, the Society of Wood Science and Technology, the Northeastern Loggers Association, the New England and Keystone Kiln Drying Associations, and several other related organizations. We also continued our participation in numerous log-grading and sawmill-training sessions sponsored by Federal, State, and industry organizations throughout the area.

During the past year we participated much more actively in log-grading and sawmill-training sessions, which was indicative of the increasing interest being shown in this field of wood quality work.

Robert Brisbin rejoined the Station as assistant wood technologist in the Division after his Army service. He is working primarily on mill-recovery and log-grade studies.

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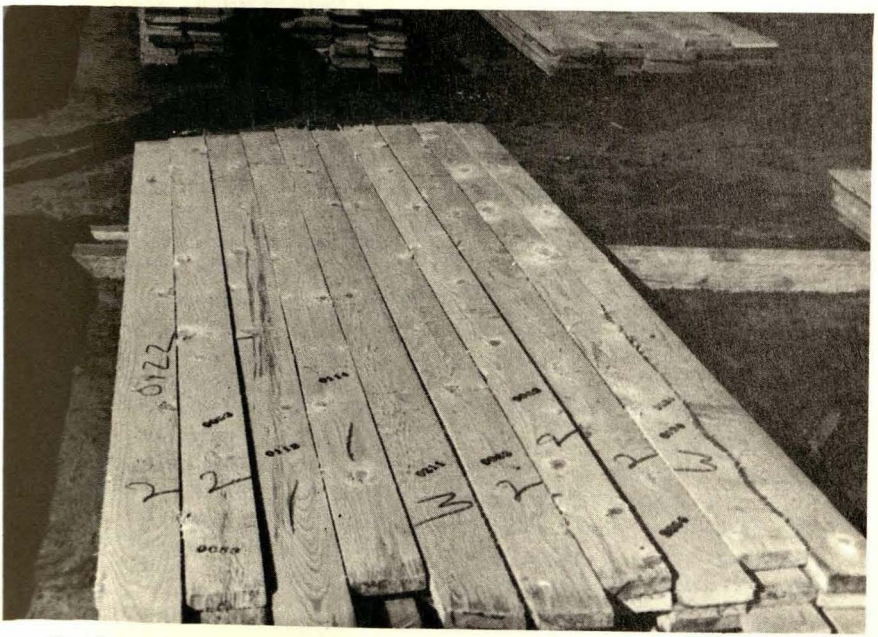
TIMBER QUALITY

FIELD work on the red, jack, and white pine log- and tree-grade developmental studies conducted on the Chippewa National Forest and Red Lake Indian Reservation in northern Minnesota was completed in November 1964. The combined studies involved 250 red pine trees (1,005 logs) 160 jack pine trees (504 logs) and 75 white pine trees (290 logs). Approximately 145,000 board feet of lumber were produced from these trees.

In addition to obtaining actual lumber grade-yield data on all red and jack pine trees, each tree was first evaluated for possible alternate products such as piling and poles as well as pulpwood in upper stem portions. We are now editing the field data from these studies and data processing is scheduled for the coming year.

A joint United States and Canadian log- and tree-quality evaluation conference was held at Ottawa early in 1964.



Grade-marked lumber from the red, jack, and white pine log- and tree-grade development studies. Log identification number is stamped on each board. Field work for the studies was completed in November 1964.

Project leaders of the Forest Service log- and tree-grade program and representatives of the Canadian Department of Forestry attended. Basic concepts of timber-quality relationships, review of progress of various projects and investigation of areas of mutual interest between the two countries were the chief topics of discussion.

As a result of this conference, the northern softwood project leader actively participated in a white pine log-grade-yield study in southern Ontario in early November. The objectives of this study were to compare and to evaluate Canadian and U. S. Forest Service log-grade field techniques and procedures (and to resolve differences whenever possible), and to evaluate the discrepancies in lumber grade of the two lumber manufacturing associations involved.

The project cooperated with the Pack Demonstration Forest (State University of New York) at Warrensburg, N. Y., in the sawing of a second group of pruned white pine logs. The purpose of this second study was to evaluate differences in lumber-grade yields from pruned logs of different sizes, and growth rates — as affected by different sawing methods (taper sawing vs. non-taper sawing; and clear-edged, center-cut boards vs. knotty-edged, center-cut boards). A third and final group of pruned logs will be processed next spring and a report on findings will be prepared at that time.

A transfer of the white pine log-grade data (northeastern studies) from Remington Rand to International Business Machine cards is now being made and all study data — including the Southern Appalachian and Upper Michigan studies — are being punched for processing through the new 7090 computer at New Haven.

The supply of the Station publication "A Guide to Hardwood Log Grading," by M. D. Ostrander and others, has been depleted by heavy demand. A revised edition will be published early in 1965. Principal revisions are in the hardwood veneer section of the paper.

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FOREST ENGINEERING RESEARCH

THE Station's forest engineering research unit was established at Morgantown, W. Va., on July 20, 1964, with the arrival of the project leader, Homer W. Parker, a mechanical engineer, from the Washington Office of the Forest Service. A temporary project office was located on the Evansdale Campus of West Virginia University.

BUILDING STATUS

A proposed building to house the unit is being designed by Robert J. Bennett & Associates, Morgantown architectural firm. In addition to forest-engineering research, the new facility will house activities in forest disease and wildlife-habitat research.

Plans for the two-story structure call for a total of 19 offices, a wildlife laboratory, a tree disease laboratory, an instrument laboratory, a library, a conference room, a small photo laboratory, a model shop, and a small cold storage room — in 13,500 square feet of floor space. The facility will be located on the Evansdale Campus on a 2.6-acre tract leased by West Virginia University to the Federal Government on a no-charge basis.

PROJECT STATUS

The first task has been to start a comprehensive background study and to begin work on the problem analysis. An exhaustive search of the available literature has been made; considerable liaison has been established with University personnel; and a number of contacts have been made with key people in industry and various logging operations. And before opening the project office in Morgantown the project leader traveled to various Forest Service facilities to collect background data and to obtain ideas on essential projects for aiding the Appalachian area.

Through a combination of contacts with various Forest Service facilities, universities, industry, loggers, consultants, and an intensive study of the literature, 96 potential problem areas were defined. A study is being made at this time to ascertain which problems should be given highest priority.

COOPERATIVE RESEARCH

We plan to conduct a considerable portion of certain types of research in cooperation with universities. Work has begun to find out the potential capacities and capabilities of various facilities within the Appalachian Region that will be served by this unit. We have already determined that more than adequate cooperative research capacity exists to handle any planned or proposed studies in view.

PUBLICATIONS

in 1964 by staff members and cooperators of the Northeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture.

General

*Northeastern Forest Experiment Station.
1964. **Annual report, 1963.**
U. S. Forest Serv. Northeast. Forest Expt. Sta., 110 pp., illus. Upper Darby, Pa.
A summary of research activities and accomplishments in timber management, forest insects and diseases, forest economics, watershed management, forest utilization, forest recreation, wildlife habitat, and forest products marketing. Annotated list of publications.

*Northeastern Forest Experiment Station.
1964. **Hubbard Brook Experimental Forest.**
U. S. Forest Serv. Northeast. Forest Expt. Sta. 13 pp., illus. Upper Darby, Pa.
A brochure describing watershed research at Hubbard Brook and the major water problems of the mountainous forested region of New England — low flows, floods, and water quality. Vegetation, geology, soils, climate, and research facilities of the Experimental Forest are described.

*Northeastern Forest Experiment Station.
1964. **The Fernow Experimental Forest at Parsons, West Virginia.**
U. S. Forest Serv. Northeast. Forest Expt. Sta., 12 pp., illus. Upper Darby, Pa.
A brochure that describes the Fernow Forest and provides directions for a self-guided tour of some of the timber and watershed research study areas on the Forest.

*Northeastern Forest Experiment Station.
1964. **The Timber and Watershed Laboratory at Parsons, West Virginia.**
U. S. Forest Serv. Northeast. Forest Expt. Sta., 6 pp., illus. Upper Darby, Pa.
Describes the Northeastern Station's new laboratory at Parsons, West Virginia, and the associated programs of timber- and watershed-management research on the nearby Fernow Experimental Forest.

*Northeastern Forest Experiment Station.
1964. **The Forest Products Marketing Laboratory at Princeton, West Virginia.** North. Logger 12 (8): 14-15, 40, illus.
Describes the new marketing research laboratory at Princeton, W. Va., and the

*Copies or reprints available from the Northeastern Forest Experiment Station, U. S. Forest Service, 102 Motors Avenue, Upper Darby, Pa.

research program directed toward improving markets for Appalachian hardwood timber products.

*Parker, H. W.
1964. **The U. S. Forest Service's forest engineering project at Morgantown, West Virginia.** South. Lumberman 209(2609): 114.
To provide basic engineering research for developing efficient equipment and methods for logging in the Appalachian Mountains, a forest engineering project has been established at Morgantown, W. Va. A research program is being planned, staff is being recruited, and a laboratory building will be constructed.

Timber Management

Atkinson, Oscar R.
1964. **Vegetative propagation problems with sugar maple.** Northeast. Forest Tree Improve. Conf. Proc. 11: 12-15.
Reviews progress of the Northeastern Forest Experiment Station and University of Vermont in developing techniques for the vegetative propagation of sugar maple. Procedures for rooting cuttings are fairly well developed. The major problem is to find better ways of over-wintering the rooted cuttings.

*Curtis, Robert O.
1964. **A stem-analysis approach to site-index curves.** Forest Sci. 10: 241-256, illus.
In comparison with conventional methods of constructing site-index curves, the use of stem analysis provides a better definition of curve shape, a means of avoiding bias from age-site correlations, and an opportunity to detect any lack of proportionality among sites in height/age curves. Detailed description of the construction of site-index curves using stem analysis.

*Curtis, Robert O., and Boyd W. Post.
1964. **Basal area, volume, and diameter related to site index and age in unmanaged even-aged northern hardwoods in the Green Mountains.** Jour. Forestry 62: 864-870, illus.
Basal area, total cubic volume, and mean diameter of even-aged, unmanaged stands were related to age and composite site index (all species combined). The results have practical application for management purposes on acid till soils in the Green Mountains of Vermont.

*Curtis, Robert O., and Boyd W. Post.
1964. **Estimating bulk density from organic matter content in some Vermont forest soils.** Soil Sci. Soc. Amer. Proc. 28: 285-286, illus.
The direct determination of bulk density in stony forest soils is difficult. An equation was developed that related bulk density to organic matter content (weight loss-on-ignition) for the A and B horizons of some acid till forest soils in Vermont. This equation provides estimates with a degree of accuracy satisfactory for most purposes.

*Davis, Grant.
1964. **Second-year results of hybrid poplar test plantings on bituminous strip-mine spoils in Pennsylvania.** U. S. Forest Serv. Res. Note NE-19,

7 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Because hybrid poplars had shown some promise for revegetating strip-mine banks, a broad screening test was designed to determine the relative suitability of 60 clones. Two-year survival and height measurements revealed great variability among the six planting sites, apparently related to differences in spoil acidity. Certain hybrid poplar clones will be suitable for planting all but the most acid spoils.

Doolittle, Warren T.

1964. **Discussion of soil-site papers at Syracuse SAF Meeting.** *In* **Applications of soils information in forestry,** pp. 45-47. N. Y. State Univ. Coll. Forestry and Coll. Agr., 94 pp., illus.

Emphasizes the importance of attempting to rate site productivity on the basis of soil classifications and properties. Researchers in forestry and soils should narrow the scope of their problems to enable greater intensification of study, and should remain open to new approaches and techniques.

*Fenton, R. H.

1964. **Production and distribution of sweetgum seed in 1962 by four New Jersey stands.** U. S. Forest Serv. Res. Note NE-18, 6 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Amount of seed caught in open areas decreased sharply with distance from seed source, but direction from source had only moderate influence. Study results suggest that the width of a clearcut opening should not exceed four times stand height and that, in seed-tree cuttings, two to four prolific trees per acre should be retained.

*Fenton, Richard H., and Adna R. Bond.

1964. **The silvics and silviculture of Virginia pine in southern Maryland.** U. S. Forest Serv. Res. Paper NE-27, 36 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Describes the silvical characteristics of Virginia pine, one of the major forest tree species in southern Maryland, and recommends silvicultural treatments. Recommendations based primarily on research by the U. S. Forest Service and the Maryland Department of Forests and Parks.

*Frank, Robert M.

1964. **A guide for screen and cover planting of trees on anthracite mine-spoil areas.** U. S. Forest Serv. Res. Paper NE-22, 50 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Areas disturbed by coal mining in Pennsylvania were mapped, and potential planting sites necessary to screen them from view or to cover them were delineated. Number of seedlings needed for a planting program was estimated. Areas shown on maps were classified according to kind of spoil, density of present tree cover, and visibility. Maps were prepared for major communities, counties, and for the entire Anthracite Region.

Gabriel, William J.

1964. **Report of the NEFTIC Committee on hardwood tree improvement.** Northeast. Forest Tree Improve. Conf. Proc. 11: 58-59.

Reports progress of the NEFTIC-sponsored sugar maple survey in selecting trees of high sugar content during the 1963 sugaring season. Of 84 promising trees selected, the sweetest had a sugar reading of 8%.

Gabriel, William J.

1964. **Selection of sugar maples for high sugar content in sap — development of procedures.** Northeast. Forest Tree Improve. Conf. Proc. 11: 8-11, illus.

Describes original and revised procedures used for the NEFTIC-sponsored survey of sugar bushes in Maine, Vermont, New Hampshire, and New York to select sugar maple trees of high sugar content. Current criteria for selection are that the sugar content of a selected tree must exceed that of the sweetest standard — a comparable adjacent tree — by 0.5% and must be proportionately higher than the average of the standards by 30%.

*Gibbs, Carter B.

1964. **Spiegel-relascope reliable for measuring total height of standing hardwoods.** Jour. Forestry 62: 580.

Height measurements taken on four species of Appalachian hardwoods with a Spiegel-relascope did not differ significantly from tape measurements on the same trees after felling. Average heights based on relascope measurements will probably be sufficiently accurate for general purposes.

*Hart, Arthur C.

1964. **Spruce-fir silviculture in northern New England.** Soc. Amer. Foresters Proc. 1963: 107-110.

Discusses the silvical characteristics and silviculture of red, white, and black spruce, and the associated balsam fir. There is a trend toward more partial cutting, which is resulting in more uneven-aged stands with higher proportions of spruce.

*Hart, Arthur C.

1964. **The Penobscot management-intensity demonstration plots.** U. S. Forest Serv. Res. Paper NE-25, 24 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Reviews 9-year results in terms of costs and returns, growth, and development on four 10-acre plots in central Maine that were established to demonstrate four management practices used in or adapted to spruce-fire stands: commercial clear-cutting, diameter-limit cutting, selection cutting, and intensive selection cutting. Discusses stand-structure goals, and advantages and disadvantages of each management practice.

Hough, Ashbel F.

1964. **20-year vegetation changes on the Tionesta area.** Pa. Forests 54 (4): 81, 87, illus.

Heavy deer pressure is causing a decline in understory vegetation in the Tionesta Natural and Scenic Area. Unless the deer population is controlled, the natural or climax virgin forest may not be perpetuated; and much of the scientific, cultural, and historical value of the area may be lost.

Hoyle, Merrill C., and Donald L. Mader.

1964. **Relationships of foliar nutrients to growth of red pine in western Massachusetts.** Forest Sci. 10: 337-347.

Use of foliar analysis for assessing site productivity appears to offer some advantages over soil analysis. Multiple regression analysis applied to foliar nutrient data from red pine stands indicated that various measures of growth exhibited different relationships to foliar nutrient levels.

*Huntzinger, Harold J.

1964. **Germination, survival, and first-year growth of black cherry under various seedbed and supplemental treatments.** U. S. Forest Serv. Res. Note NE-26, 6 pp. Northeast Forest Expt. Sta., Upper Darby, Pa.

Discusses the effects of various combinations of five seedbed and four supplemental treatments on black cherry germination and first-year growth. Drastic reduction and continued suppression of the herbaceous competition for at least 1 year — and perhaps longer — are apparently required for good seedling growth.

*Leak, William B.

1964. **Some comments on "The development of an optimal program for sustained-yield management."** Jour. Forestry 62: 828-829.

Comments upon an article by Daniel P. Loucks, which appeared in Jour. Forestry 62: 485-490, with particular regard to the application of linear programming to yield regulation under even-aged vs. uneven-aged management, the desirability of incorporating thinning yields into such an analysis, and the possibility of including constraints that will insure the development of a balanced age distribution.

*Leak, William B.

1964. **An expression of diameter distribution for unbalanced, uneven-aged stands and forests.** Forest Sci. 10: 39-50, illus.

For a wide variety of northern hardwood stands, the quotients between numbers of trees in successive 4-inch d.b.h. classes were found to be linearly related to d.b.h.; thus the diameter distributions for these stands can be represented by the slope and intercept of this linear relationship.

*Leak, William B.

1964. **Estimating maximum allowable timber yields by linear programming.** U. S. Forest Serv. Res. Paper NE-17, 9 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.

The determination of allowable cut is an important problem facing both private and public forestry agencies. General equations and two simple hypothetical examples are presented to demonstrate how maximum allowable yields from unbalanced even-aged forests can be approached through linear programming.

Little, S.

1964. **Recent results in silvicultural research and their implications.** Soc. Amer. Foresters Allegheny Sect. Proc. 1964: 12-26.

Discusses the status of silvicultural knowledge for the common forest types in the Allegheny region with regard to harvest cuttings, measures supplementing harvest cuttings, thinnings and stand density, stand improvement and conversion, seeding and planting, and site studies.

*Little, S., and R. H. Fenton.

1964. **1963 results from injector treatments of New Jersey and Maryland hardwoods.** Northeast. Weed Control Conf. Proc. 18: 584-590.

To provide local guidelines on tree injection methods, a study was made to compare two formulations of 2,4,5-T, three concentrations, four seasons, and three stand conditions. Second-year results indicate that complete, low frills are best; either the amine or ester of 2,4,5-T is suitable; a concentration of 80 pounds aehg. is best for first-year kills while 20-40 pounds aehg. will suffice for acceptable second-year kills; and 1.5 ml. of solution per cut is enough.

*Little, S., and J. J. Mohr.

1964. **Disking to convert hardwood-loblolly pine stands to pine in eastern Maryland.** U. S. Forest Serv. Res. Paper NE-20, 17 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

When pine stands on old fields are harvested, relatively worthless hardwoods will take over the site unless effective cultural treatments are employed. Single or double disking resulted in better pine establishment than blading with a bulldozer. But disking treatments apparently will have to be supplemented by later selective release.

*Little, S., and H. A. Somes.

1964. **Releasing pitch pine sprouts from old stools ineffective.** Jour. Forestry 62: 23-26, illus.

After 6 years, released pitch pine sprouts showed little promise of developing into merchantable trees in the Plains Region of southern New Jersey. Apparently an acceptable crop of timber could be produced on these sites only by converting to stands of seedling origin.

*Little, S., and H. A. Somes

1964. **Local sources of loblolly pine in Maryland and shortleaf pine in New Jersey outgrow southern stocks.** U. S. Forest Serv. Tree Planters' Notes 67: 18-19.

As part of a Southwide study, compares various seed sources within a loblolly pine plantation in eastern Maryland and a shortleaf pine plantation in southern New Jersey. Local sources outgrew the other sources from farther south and also produced a greater proportion of good stems.

*Little, S., and H. A. Somes.

1964. **Root systems of direct-seeded and variously planted loblolly, shortleaf, and pitch pines.** U. S. Forest Serv. Res. Paper NE-26, 13 pp., illus., Northeast. Forest Expt. Sta., Upper Darby, Pa.

Describes the root systems of 2-year-old seedlings from direct seeding and 3-year-old seedlings from planting as 1-0 and 2-0 stock in three ways: center hole, poor slit, and good slit. Only seedlings from direct seeding had normal root systems. The amount of distortion in root systems varied with planting method, but root systems of 1-0 stock showed greater recovery than did those of 2-0 stock.

*McConkey, Thomas W.

1964. **Some factors affecting hardwood control with mistblower applications of 2,4,5-T.** Northeast. Weed Control Conf. Proc. 18: 571-576.

Results of 2,4,5-T mistblower treatments on hardwood species often are erratic. Two mistblower tests in a young stand of paper birch revealed that mid-June to mid-July treatments were best; an oil carrier is better than water; complete coverage of the crowns is important; and that the understories in stands of sensitive, desirable species can be reduced without damaging the overstory by using an invert emulsion. Some practical guides for mistblowing treatments.

McConkey, Thomas W.

1964. **Comments (on paper Time-tested silvicultural practices in the development of quality white pine timber trees, by Clifford H. Foster).** Soc. Amer. Foresters Proc. 1963: 97.

Discusses Foster's method of growing large, high-quality trees and concludes

that this method may not be the best for encouraging a new, high-quality stand of regeneration.

*McConkey, Thomas W.
1964. **Direct seeding of pine and spruce in southwestern Maine.** U. S. Forest Serv. Res. Paper NE-24, 13 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
The possibilities of direct seeding in New England have not been fully explored. A direct-seeding test in southwestern Maine with five coniferous species revealed that seedbed preparation, shading, season of sowing, year, soil type, and various interactions all had appreciable effects on seed germination and first-year establishment of some or all species.

*McConkey, Thomas W.
1964. **White pine pruning and branch growth.** U. S. Forest Serv. Res. Note NE-27, 6 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Results of a study in Maine to determine how pruning influences residual branch growth on young white pine trees. Over a 3-year study period no significant differences in growth of residual branches were attributable to pruning. However, growth of the main stems was reduced.

Mader, D. L., and M. C. Hoyle.
1964. **An inexpensive portable unit for perchloric acid digestions and semimicro-Kjeldahl determinations.** Soil Sci. 98: 295-299.
A portable, compact, inexpensive unit is described for carrying out multiple semimicro-Kjeldahl and wet digestions for tissue analysis employing perchloric acid mixtures. This unit can provide considerable analytical capability in situations where space, facilities, or funds may prevent installation of larger permanent units.

*Marquis, David A., John C. Bjorkbom, and George Yelenosky.
1964. **Effect of seedbed condition and light exposure on paper birch regeneration.** Jour. Forestry 62: 876-881, illus.
A study of germination and 1-year development in patch cuttings reveals that mineral soil and shade are generally most favorable to germination and survival of paper birch. Light, moisture, and temperature relationships are discussed. Practical seedbed treatments and cutting methods are needed to provide the requisite conditions for germination, survival, and growth.

Santamour, Frank S. Jr.
1964. **Some observations on needle variegation in pines.** Univ. Pa. Morris Arboretum Bul. 15: 49-51, illus.
Knowledge of foliar variegation is useful in determining and tracing patterns of inheritance. Describes in detail the abnormal needle coloration for variegated types of *Pinus densiflora, P. thunbergii,* and *P. griffithii.* Preliminary controlled-pollination studies indicate that dragon-eye markings in *P. thunbergii* are controlled by a single recessive gene.

Santamour, Frank S. Jr.
1964. **Is there genetic resistance to the white pine weevil in *Pinus strobus?*** Northeast. Forest Tree Improve. Conf. Proc. 11: 49-51.
The selection or development of genetically resistant trees is a possible approach to white pine weevil control. In a 14-year-old plantation in Williamstown, Mass.,

weevil damage varied significantly among the 8 progenies represented, which were derived from open pollinations or artificial crosses among 6 ornamental trees. Possibly this apparent resistance could be related to chemical differences.

*Santamour, Frank S., Jr., and Frank E. Cunningham.
1964. **Variation in sugar content in a budded sugar maple clone.** U. S. Forest Serv. Res. Note NE-17, 4 pp., Northeast. Forest Expt. Sta., Upper Darby, Pa.

The sugar contents of ramets of one clone budded on wildling rootstocks varied fully as much as the sugar contents of adjacent wildling seedlings in an ornamental nursery, apparently because of rootstock influence. Therefore grafting may not be well suited for propagating sugar maples selected for high sugar yield.

*Snow, Albert G., Jr.
1964. **The search for "blue-blood" sugar maples.** Rural New Yorker 114 (5999): 18-19, illus.

Describes the cooperative sugar maple research project of the University of Vermont and the Northeastern Station. The search for exceptionally high-yielding trees for use in a breeding program is emphasized.

*Snow, Albert G., Jr.
1964. **Maple sugaring and research.** Jour. Forestry 62: 83-88, illus.

In the past, maple sugar research in the Northeast has been concentrated upon production and processing methods. The need for research on the tree itself is now being met by a cooperative sugar maple project conducted by the Vermont Agricultural Experiment Station and the Northeastern Forest Experiment Station. This research aims toward a better understanding of the factors associated with sap sweetness and sap flow.

*Trimble, G. R. Jr.
1964. **An equation for predicting oak site index without measuring soil depth.** Jour. Forestry 62: 325-327, illus.

Soil-site index equations are most suitable for practical application when based upon easily-measured variables. The variable of soil depth was eliminated from a previous equation, with little loss in accuracy, to provide a new equation based upon the easily-measured variables of aspect, slope position, and slope percent. The new equation enables quicker estimates of site index, particularly where aerial photographs or topographic maps are available.

*Yawney, Harry W.
1964. **Oak site index on Belmont limestone soils in the Allegheny Mountains of West Virginia.** U. S. Forest Serv. Res. Paper NE-30, 16 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

To provide a method of predicting site index for the limestone Belmont soils in West Virginia, a regression equation was developed utilizing aspect, slope position, slope percent, and soil depth as independent variables. A comparison between site-index values from this equation and those predicted from an equation developed for sandstone and shale soils revealed the productive superiority of the limestone soils.

Forest Fire

Banks, Wayne G.

1964. **Nearly 10,000 forest fires annually in the Northeast. Who starts these fires? How and why?** Northern Logger 12 (12): 18, 50.

Better information on fire causes in the Northeast would assist in planning better prevention campaigns. To speed up progress on this phase of fire research, the Northeastern Station has begun studies of fire causes. Cooperation of other interested Federal, State, and private groups is sought.

*Banks, W. G., and S. Little.

1964. **The forest fires of April 1963 in New Jersey can point the way to better protection and management.** Soc. Amer. Foresters Proc. 1963: 140-144.

An analysis of the forest fires of April 1963 (fire behavior, weather conditions, prevention and suppression actions) pinpoints weaknesses in the ability of present fire-control organizations to cope with extraordinary wildfires. Recommendations for strengthening the fire-control system.

Banks, W. G., and Silas Little.

1964. **The forest fires of April 1963 in New Jersey can point the way to better protection and management.** U. S. Forest Serv. Fire Control Notes 25 (3): 3-6, illus.

See above.

Forest Economics

Hagenstein, Perry R.

1964. **Economic research — in the Northeast.** Soc. Amer. Foresters Allegheny Sect. Proc. 1964: 63-68.

Past work in forest economics research in the Northeast has dealt largely with the economics of timber production. The emphasis is now shifting toward analysis of problems associated with programs and planning, both public and private.

*Hagenstein, Perry R.

1964. **The location decision for wood-using industries in the northern Appalachians.** U. S. Forest Serv. Res. Paper NE-16, 36 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

The costs of wood, labor, and shipping the final product to markets are the most important factors affecting the plant-location decision in four wood-using industries — lumber, particle-board, woodpulp, and furniture. The relative importance of these factors varies considerably among the four industries examined.

*Hagenstein, Perry R.

1964. **Timber industry opportunities in selected areas of West Virginia.** U. S. Forest Serv. Res. Paper NE-28, 72 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Five representative areas in West Virginia were evaluated as locations for new wood-using plants. All had sufficient quantities of the necessary production factors

for the lumber, particle-board, woodpulp, and furniture industries. Prospects for new plants in the State are somewhat better for the lumber and woodpulp industries than for the furniture and particle-board industries.

Manthy, R. S., and L. M. James.
1964. **Marketing pulpwood in selected areas of the North Central Region.** Mich. Agr. Expt. Sta., Res. Bul. 6, 120 pp.
An analytical description of the movement of pulpwood from the stump to the mill in the North Central Region. Alternative procurement and marketing activities of producers, middlemen, and pulp and paper companies are analyzed and compared. Detailed cost and price information, and recommendations for improving the marketing system are presented.

Manthy, R. S., C. D. Rannard, and V. T. Rudolph.
1964. **The profitability of red pine plantations.**
Mich. Agr. Expt. Sta. Nat. Resources Res. Rpt. 11, 11 pp.
Provides estimates of the financial return forest investors can reasonably expect to earn from red pine plantations. The analytical technique employed can be performed on a standard office calculator and used to determine the relative profitability of investments in plantations of any species.

Marty, Robert.
1964. **The application of research results.**
Soc. Amer. Foresters Allegheny Sect. Proc. 1964: 88-92.
Discusses the trend toward increasing specialization and depth of inquiry in forest research and the influence this trend has on forest practice. Concludes that more research effort will be devoted to integrating and summarizing research results for practitioner use.

*Marty, Robert.
1964. **Analyzing uncertain timber investments.**
U. S. Forest Serv. Res. Paper NE-23, 21 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Presents a method of appraising and comparing timber-investment projects, recognizing the uncertainty of cost, yield, and price estimates, and showing to what degree this uncertainty can be ignored in choosing among competing projects. Briefly introduces some formal decision rules useful in making final choices.

*Marty, Robert, and D. Gordon Mott.
1964. **Evaluating and scheduling white-pine weevil control in the Northeast.** U. S. Forest Serv. Res. Paper NE-19, 56 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Discusses the biology and incidence of damage by the white-pine weevil, resulting volume and quality losses, and the cost and value of control. Presents procedures for estimating control profitability, for scheduling treatment of individual stands, and for planning control programs involving many stands.

*Webster, Henry H.
1964. **Economic research for more effective assistance to woodland owners.** Land Econ. 40: 371-380.
Identifies subject areas in which economic research would increase the effectiveness of forestry assistance to woodland owners. These subject areas are grouped in three major categories: (1) economics of small woodland management;

(2) economics of public and private forestry assistance programs; and (3) dynamic aspects of small woodland ownership and assistance.

Forest Survey

Bickford, C. Allen.
1964. **On successive forest inventories.**
Soc. Amer. Foresters Proc. 1963: 25-30.
Three alternative methods are available for remeasuring plots: independent samples, a fixed sample, and sampling with partial replacement. The author identifies the significant factors in choosing which method to use to achieve desired accuracy at least cost.

*Ferguson, Roland H.
1964. **The timber resources of West Virginia.**
U. S. Forest Serv. Resource Bul. NE-2, 121 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
A report on a resurvey 12 years after the initial forest survey made by the U. S. Forest Service, presenting statistical findings on forest-land area, timber volume, and growth. Reports an explosion of timber supply in West Virginia in the 12-year period between surveys. Report contains 98 tables of statistical data, including detailed data for counties.

Northeastern Forest Experiment Station.
1964. **Pulpwood production in New York, 1962.**
U. S. Forest Serv. Northeast. Forest Expt. Sta., 7 pp. Upper Darby, Pa.
A report on pulpwood production in 1962, with emphasis on the form, species, and geographical source of pulpwood produced in the State. The information was obtained by mail questionnaires.

Forest Recreation

*Burke, Hubert D.
1964. **Picnic table use depends upon distance from parking area.**
Jour. Forestry 62: 752-753.
Picnic tables in two recreation areas were classed into 50-foot zones in relation to automobile parking areas to determine how distance from parking affected table use. Definite preference was found for tables near parking; visitors spread their lunches on the grass rather than walk 400 feet to a table.

Burke, Hubert D.
1964. **Needed research in outdoor recreation.** *In* **Time, space and demand for natural resources.** Soil Conserv. Soc. Amer. Ann. Mtg. Proc. 19: 49-57.
Defines types of studies needed, levels of application of research results, and obstacles to conducting effective research in outdoor recreation. Stresses social, cultural, and economic aspects of the demand for recreational space. Sees need for a standard terminology.

*LaPage, Wilbur F.
1964. **Under the camper's feet — a study of ground cover.** Recreation Jour. 5: 103-104.
Some early results of a continuing study of vegetation under different intensities of recreational use on a campground in northwestern Pennsylvania. Campsites that received light use lost only about 10% of their ground cover in the first season, whereas sites that received heavy use lost more than 60%.

LaPage, Wilbur F.
1964. **Some new ideas from recreation research.** Soc. Amer. Foresters New England Sect., 17 pp.
Emphasizes the desirability of looking at resource problems in a social context, including both aggregate trends and individual motivations. Explains current and proposed studies of forest recreationists under way by the Northeastern Forest Experiment Station.

Shafer, Elwood L., Jr.
1964. **Forest Service research in outdoor recreation in the Northeast.** *In* The outdoor recreation phenomenon, pp. 61-65. N. Y. State Coll. Agr. at Cornell Univ., Ithaca.
Recommends that recreation be studied on a need-to-know basis rather than on a need-to-practice basis. Discusses some of the problems involved and the tools and methods needed to conceptualize and conduct recreation-research studies.

*Shafer, Elwood L., Jr.
1964. **The photo-choice method for recreation research.** U. S. Forest Serv. Res. Paper NE-29, 10 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Series of photographs showing different types and use costs for recreation facilities such as swimming beaches, picnic areas, campsites, and fireplaces were used in personal interviews in State parks in Pennsylvania to measure visitor preferences.

*Wagar, J. Alan.
1964. **Estimating numbers of campers on unsupervised campgrounds.** U. S. Forest Serv. Res. Paper NE-18, 16 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Within a large sampling area the numbers of campers may rise and fall in uniform response to such factors as weather, day of the week, vacation periods, insect activity, and fishing seasons. Where this common pattern exists, the number of campers on a supervised group of campgrounds may be related to campers on all campgrounds by regression and ratio techniques.

Wagar, J. Alan.
1964. **The carrying capacity of wild lands for recreation.** Forest Sci. Monog. 7, 24 pp., illus.
Analyzes the carrying capacity problem in terms of (1) the impact of the recreational environment on people, (2) the impact of the people on the recreational environment, and (3) management procedures to modify these reciprocal impacts. Discusses human as well as ecological management considerations that must go into administrative decisions to limit recreational use.

Wagar, J. Alan.
1964. **The insolation grid.**

Ecology 45: 636-639, illus.
Describes a device for comparing the amounts of direct sunlight received by partially shaded plots at different locations during an entire growing season. The device superimposes 100 dots on the horizon-to-horizon swath of sky through which the sun passes between selected dates.

Watershed Management

*Hornbeck, James W.
1964. **The importance of dew in watershed-management research.** U. S. Forest Serv. Res. Note NE-24, 5 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Dew deposition was measured at the Fernow Experimental Forest in West Virginia in a recording rain gage modified to accommodate a section of live turf. Conclusion: Dew accumulation is not large enough to warrant consideration as a factor in watershed-management research.

*Hornbeck, J. W., and K. G. Reinhart.
1964. **Water quality and soil erosion as affected by logging in steep terrain.** Jour. Soil and Water Conserv. 19 (1): 23-27, illus.
A study in West Virginia has shown that excessive damage to water quality can be avoided even when logging on steep terrain. Measured maximum stream turbidities were 56,000 ppm. on a commercial clear-cut area and only 25 ppm. on an intensive selection-cut watershed. Most of the damage to water quality occurred during and immediately after logging. Recommended practices include planning of the logging operation; proper location, drainage, and grade of skidroads; and timely completion of the operation on any specific area.

Lull, Howard W.
1964. **Ecological and silvicultural aspects.** *In* **Handbook of applied hydrology:** 6-1 to 6-30, illus. McGraw-Hill Book Co., New York.
The proportion of precipitation intercepted by forest vegetation, the rate of infiltration of water into the soil, and the amount of water evapotranspired tend to increase as ecological succession proceeds from the preclimax to the climax condition, or with silvicultural practices that increase the density of vegetation. Exceptions are noted.

Lull, Howard W.
1964. **Some recent results from forest watershed research.** Soc. Amer. Foresters Allegheny Sect. Proc. 1964: 44-48.
Recent research results suggest some new concepts in forest-streamflow relationships and some practical management applications. Discusses research in water quality, overland peak flows, snowmelt, small watershed research applications to large watersheds, streamflow source, and the use of silvicides on watersheds.

*Lull, Howard W., and Donald R. Satterlund.
1964. **What's new in municipal watershed management.** Soc. Amer. Foresters Proc. 1963: 171-175.
Recent evidence shows that forested watersheds can produce high-quality water when carefully logged. A compilation of watershed research results as to the effects of forest treatment on water yield showed that clear cutting generally

has increased first-year water yields about 4 to 8 inches. Reforestation over a 20-year period has reduced annual yield about 5 inches.

*Reigner, Irvin C.
1964. **Calibrating a watershed by using climatic data.** U. S. Forest Serv. Res. Paper NE-15, 45 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

In a single-watershed calibration of the experimental Dilldown Watershed in Pennsylvania, equations were developed for predicting annual runoff and monthly water loss or runoff. The basic relationships were developed from streamflow, climatic, groundwater, and soil-moisture records; but the final equations were expressed in terms of runoff and climatic variables only.

*Reigner, Irvin C.
1964. **Evaluation of the trough-type rain gage.** U. S. Forest Serv. Res. Note NE-20, 4 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Trough gages used to measure throughfall under vegetation and rainfall in the open at the Dilldown Watershed in Pennsylvania gave deficient catches due to rainfall splashing out of the trough. The deficiency was inversely related to the slope of the trough and correction regressions were computed.

*Reigner, Irvin C.
1964. **How to make a wind-movement recorder from any spare drum-type recorder.** U. S. Forest Serv. Res. Note NE-21, 4 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

A recording instrument that has a clock-driven chart drum and pen-arm assembly may be converted to a wind-movement recorder with a $5 expenditure for an electromagnet, dry cells, and assorted small hardware. Dry cells are connected in series with the anemometer contacts and the electromagnet. Closure of contacts activate the magnet, a counterweight, and the pen-arm.

*Reigner, Irvin C., and John J. Phillips.
1964. **Variations in bulk density and moisture content within two New Jersey Coastal Plain soils, Lakeland and Lakehurst sands.** Soil Sci. Soc. Amer. Proc. 28: 287-289.

A relationship between bulk density and soil depth plus stone content was developed. From this, bulk density was estimated for each soil-moisture sample in five 1-foot layers. Moisture content by weight for each 1-foot layer was converted to moisture content by volume by applying the respective estimated bulk densities.

*Reigner, I. C., W. E. Sopper, and R. R. Johnson.
1964. **Control of riparian vegetation with phenoxy herbicides and the effect on streamflow quality.** Northeast. Weed Control Conf. Proc. 18: 563-570.

Vegetation along the stream channels of two small forested watersheds was sprayed with 2,4,5-T by means of a mistblower. Water samples revealed very little contamination. Conclusion: If mist-sprayed with normal precautions, phenoxy herbicides can be used on municipal watersheds without danger.

*Reinhart, K. G.
1964. **Approximating soil-moisture storage in experimental watersheds by means of precipitation and streamflow records.** Soil Sci. Soc. Amer.

Proc. 28: 575-578, illus.

Reliable estimates of total soil-moisture storage capacity of a watershed may be difficult to obtain because of variations in and difficulties of measuring soil depth, root depth, soil texture, bulk density, stone content, and moisture content. Precipitation minus runoff — in selected periods when ample precipitation follows a dry spell — provides the estimate of soil-moisture storage capacity.

Reinhart, K. G.

1964. **Forest watershed research by the U. S. Forest Service in West Virginia.** W. Va. Water Res. Symposium Proc. 1963: 55-56.

Outlines research began in 1948 at the Fernow Experimental Forest, Parsons, W. Va. Results have shown that erosion from logging operations can be controlled by practical and economical methods, that most of the harmful effects of logging are the results of disturbance of the forest floors, and that forest management does influence water yield. Future research will involve study of the energy budget and potential evapotranspiration, snowmelt, and forest microclimate.

*Reinhart, Kenneth G.

1964. **Effect of a commercial clearcutting in West Virginia on overland flow and storm runoff.** Jour. Forestry 62: 167-171, illus.

Describes the effect of clearcutting a 74-acre gaged watershed on the Fernow Experimental Forest. The study indicated that, in judging hydrologic condition of logged areas, perhaps as much emphasis should be placed upon road conditions and forest-floor disturbance as upon the amount of timber cut and condition of the stand.

*Reinhart, Kenneth G.

1964. **Frequency of streamflow measurements required to determine forest treatment effects.** U. S. Forest Serv. Res. Note NE-23. 6 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Streamflow data from control and clearcut watersheds at the Fernow Experimental Forest were reanalyzed to determine if measurements taken once a day, twice a week, once a week, twice a month, or once a month could be used instead of continuous records. The results suggest that, under some situations, much might be learned from relatively few measurements.

*Reinhart, Kenneth G., and Robert S. Pierce.

1964. **Stream-gaging stations for research on small watersheds.** U. S. Dept. Agr. Agr. Handb. 268, 37 pp., illus.

Construction of stream-gaging stations is described, from selection of site and station design to detailed procedure for construction of a sharp-crested, 90° V-notch weir. Necessary instrumentation for measurements of water level, and station operation and maintenance, including cold weather maintenance, are discussed.

Satterlund, Donald R., and Arthur R. Eschner.

1964. **Snowmelt studies on the Tully Forest in central New York.** Eastern Snow Conf. Proc. 1964: 14-22, illus.

Accumulated figures of snowmelt for open, hardwood, and conifer areas on the Tully Forest for the winter 1961-62 were applied to the cover types of the Albright Creek (largely open) and Shackham Brook (largely forested) Watersheds and related to their actual runoff. Results suggest again that a desirable

pattern of land use on the Allegheny Plateau, for improved streamflow regimen, would be a combination of open and reforested lands.

Forest Insects

DeBoo, Robert F., John E. Dimond, and James H. Lowe, Jr.
1964. **Impact of pine leaf aphid, *Pineus pinifoliae* (Chermidae) on its secondary host, eastern white pine.** Canad. Ent. 96: 765-772.
Infestation reduces radial growth and modifies the normal pattern of annual radial growth along the length of the stem. Greatest growth reduction occurs in the lower stem, least in the top. Stem elongation is reduced only after severe crown damage by high aphid populations. Light attacks affect needle and branch growth only.

*Godwin, P. A., H. D. Rule, and W. E. Waters.
1964. **Some effects of gamma irradiation on the gypsy moth, *Porthetria dispar*.** Jour. Econ. Ent. 57: 986-990.
Pupae and larvae of the gypsy moth, *Porthetria dispar* (L.) were irradiated with a cobalt-60 gamma source. The effect of various dosages on pupal survival, adult longevity, mating success, egg numbers, egg viability, and F_1 survival are reported. The irradiation of pupae more than 9 days old with 20,000 r resulted in very few crippling defects of the treated insects and reduced egg hatch to a low level.

*Graber, Raymond E.
1964. **Impact of the white-pine cone beetle on a pine seed crop.**
Jour. Forestry 62: 499-500, illus.
Describes the effects of the white pine cone beetle (*Conophthorus coniperda* Schwarz). The beetle has caused complete crop failures for 8 consecutive years on the Massabesic Experimental Forest in Maine, and no doubt it has seriously hampered natural reproduction of white pine throughout New England.

*ODell, Thomas M., and Paul A. Godwin.
1964. **White-pine cone beetle.**
U. S. Dept. Agr. Forest Pest Leaflet 83, 7 pp., illus.
Describes the life history and habits of the white-pine cone beetle, *Conophthorus coniperda* (Schwarz). Observations in 1960 indicated that the beetle had destroyed the cone crop in many pine stands in Maine, New Hampshire, Massachusetts, Vermont, and Connecticut. The only known host of the beetle is eastern white pine (*Pinus strobus* L.).

*Waters, William E.
1964. **The insect threat to northern forests.**
Soc. Amer. Foresters Proc. 1963: 22-24.
A more inclusive concept of insect impact on forest productivity and values is needed for evaluating the real threat to northern forests. Factors involved and new techniques needed for thorough analysis are discussed. Control policy and actions with the spruce budworm, gypsy moth, and white-pine weevil are cited.

Waters, William E.
1964. **Insecticides in forest entomology.** *In* **1964 Yearbook of Science and**

Technology: 252-253. McGraw-Hill Book Co., New York.
Cites the unique conditions and requirements of forest insect control as compared with pest control for agricultural crops; describes the methods of application and the use of each insecticide; also mentions the safety precautions that are necessary in wide-scale applications of insecticides.

Forest Diseases

*Brandt, Robert W.
1964. **Ash dieback in New England and New York.**
Internatl. Shade Tree Conf. Proc. 39: 38-43, illus.
A generalized survey of present knowledge about ash dieback, covering the etiology, symptom development, control recommendations, and economic importance associated with the disease complex.

*Brandt, Robert W.
1964. **Nectria canker of hardwoods.**
U. S. Dept. Agr. Forest Pest Leaflet 84. 7 pp., illus.
Describes several species of Nectria that cause cankers. The most widespread and damaging is *Nectria galligena* Bres. Of lesser important are *N. magnoliae* on the magnoliae and yellow-poplar, *N. coccinea* on sugar maple, and *N. coccinea* var. *faginata* on American beech — in association with a scale insect. *N. mammoidea* and *N. cinnabarina* may be serious in local situations.

*Diller, Jesse D., Russell B. Clapper, and Richard A. Jaynes.
1964. **Cooperative test plots produce some promising Chinese and hybrid chestnut trees.** U. S. Forest Serv. Res. Note NE-25, 8 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.
In attempts to find a blight-resisting chestnut tree, one chinese chestnut from Nanking was proved to be superior in blight resistance, tree form, growth rate, and nut production. And one hybrid tree located in Illinois has so far proved to be the most outstanding on 15 cooperative test plots established between 1947 and 1955 on private, State, and Federal lands.

Fowler, Marvin E.
1963. **Sweetgum blight.**
Internatl. Shade Tree Conf. Proc. 39: 48-54, illus.
Discusses the history, possible causes, general symptoms, and attempts to control the blight that attacks the sweetgum (*Liquidambar styraciflua* L.). The blight remains uncertain in its etiology, and there is no known control for it in forest stands or in individual shade trees.

Giese, R. L., D. R. Houston, D. M. Benjamin, and J. E. Kuntz.
1964. **A new condition of sugar maple. Part I *of* Studies of Maple Blight.**
Univ. Wis. Agr. Res. Sta. Bul. 250: 1-20.
The impact of maple blight upon northern hardwood stands in Wisconsin. Ecological comparisons are made of healthy and diseased stands, and of stands before and after they were affected in an attempt to characterize the factors leading to disease development. A three-dimensional ordination of the stands indicated that differences existed between healthy and diseased stands prior to the onset of maple blight.

*Houston, David R., and Kenneth D. Fisher.

1964. **Sapstreak disease of sugar maple found in the Northeast.** U. S. Dept. Agr. Plant Disease Rptr. 48: 788.

Describes finding in 1963 two trees on the Proctor Maple Research Farm of the University of Vermont that were killed by sapstreak disease. The causal fungus, *Ceratocystis virescens,* was isolated from the discolored wood of one of these trees. Previously, the disease had been found on yellow-poplar in Tennessee and North Carolina, and sugar maple in upper Michigan.

Houston, D. R., and J. E. Kuntz.

1964. **Pathogens associated with maple blight. Part III *of* Studies of maple blight.** Univ. Wis. Agr. Res. Sta. Bul. 250: 58-79.

Investigations indicate that maple blight is not due to a primary pathogen but rather is the result of insect defoliation, followed in certain cases by an attack of *Armillaria mellea.* The importance is demonstrated of the critical timing of the defoliation in relation to maturation of refoliated tissues and injury by frost and severe winter conditions.

Little, Elbert L., and Jesse D. Diller.

1964. **Clapper chestnut, a hybrid forest tree.** Jour. Forestry 62: 109-110, illus.

Describes a promising new hybrid chestnut timber tree, named in honor of its originator, Russell B. Clapper, which exhibits rapid growth, good form, and apparent blight resistance. This cultivated variety (cultivar) is a backcross between a Chinese-American hybrid chestnut and the American hybrid parent.

*Shigo, Alex L.

1964. **Organism interactions in the beech bark disease.** Phytopathology 54: 263-269, illus.

Describes current knowledge about infection of American beech by *Nectria coccinea* var. *faginata* through feeding wounds of the beech scale, *Cryptococcus fagi.* Observations on the interactions of several other organisms, including saprophytic fungi, that invade after scale injury and later after death of the tree; the insects that attack the tree after the bark dies; and the parasites and predators of *N. coccinea* var. *faginata* and *C. fagi.*

Shigo, Alex L.

1964. **Factors affecting pigmentation by two wood-inhabiting fungi.** (Abs.) Phytopathology 54: 907-908.

Gives results briefly of laboratory studies with *Phialophora melinii* and *Cytospora decipiens,* two fungi isolated from discolorations in northern hardwoods. The effects of various carbon-nitrogen ratios and microelements upon pigment formation are described.

Shigo, Alex L.

1964. **The pattern of decays and discolorations in northern hardwoods.** (Abs.) Phytopathology 54: 129.

Describes the patterns of discoloration and decay that were revealed by longitudinal dissection of defective trees with a chain saw. Of major significance were the differences in patterns presented by (1) the core of discoloration that sometimes develops in northern hardwoods, and (2) the central core of true heartwood that always develops in black cherry.

*Shigo, Alex L.
1964. **The chain saw: a valuable tool for research.**
Chain Saw Age 12 (10): 8-9, illus.
A brief report on the use of the chain saw in dissecting trees to study the patterns of decay and discoloration associated with northern hardwoods.

*Shigo, Alex L.
1964. **A canker of maple caused by fungi infecting wounds made by the red squirrel.** U. S. Dept. Agr. Plant Disease Rptr. 48: 794-796, illus.
Small annual cankers on young red and sugar maples in New Hampshire were traced to wounds made by red squirrels in early spring so they could drink the sap. Organisms infecting the wounds cause damage ranging from discoloration to death of the tree.

Shigo, Alex L.
1964. **Cankers on hardwoods in New Hampshire.**
N. H. Forest Notes 81: 6-9, illus.
Describes the major canker diseases of hardwoods in New Hampshire: chestnut blight, Nectria canker, Hypoxylon canker, beech bark disease, Eutypella canker, bleeding canker, cankers caused by decay fungi, and cankers associated with other tree diseases. Most cankers are caused by fungi, and most are not lethal to the tree. Canker diseases cause more damage to hardwoods than to conifers.

*Shigo, Alex L.
1964. **Sapsucker injury to forest trees.**
N. H. Forest Notes 82: 3-6, illus.
Describes the attack of trees by the yellow-bellied sapsucker, *Sphyrapicus varius* L., and the damage and defects that may result. Discoloration, girdled stems, and internal ring shake are related to feeding wounds made by this bird.

*Shigo, Alex L.
1964. **Fungi as agents of biological control.**
N. H. Forest Notes 84: 6-8.
Reports the results of experiments to use beneficial fungi to control destructive fungi. The major obstacle is getting the beneficial fungi in the right place at the right time and in the right condition. Undoubtedly there is more biological control possible than realized, but much research is still needed to understand the organisms and their associations.

*Shigo, Alex L.
1964. **Collar crack of birch.**
U. S. Forest. Serv. Res. Note NE-22, 4 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
A condition of yellow and paper birches in which vertical cracks develop at the base of the tree. The author suggests that: (1) *Armillaria mellea* causes root rot of the birches; (2) the rot is usually followed by cracking at the base; and (3) other decay fungi invade the trees through the basal cracks after *A. mellea* has ceased to grow upward in the butt.

*Tegethoff, Alfred C., and Robert W. Brandt.
1964. **Ash die-back in New Hampshire, Vermont, Massachusetts, Connecticut, New Jersey, and Pennsylvania, 1963.** U. S. Dept. Agr. Plant Dis. Rptr. 48: 974-977.

A survey of the condition of ash trees during the summer of 1963 revealed that dying and dead ash occurred throughout much of the Northeast. In the six states surveyed, 27.2% of the ash trees inspected were dying or dead, and of these 8.9% were dead. No evidence of ash recovery was observed.

Forest Products Marketing

Anonymous.
1964. **A forestry expert talks of forestry in West Virginia.** W. Va. Progress 2 (3): 20-29.
An interview article in which Franklin R. Longwood, chief of the Northeastern Forest Experiment Station's Forest Products Marketing Laboratory at Princeton, W. Va., outlines the forestry problems in West Virginia and the purpose and programs of the Forest Products Marketing Laboratory.

Longwood, Frank R.
1964. **The forest products marketing research program of the Forest Service, USDA.** *In* **Wood for People.** Univ. Mass. Coll. Agr. Coop. Ext. Serv. Pub. 414: 44-50.
Describes the research program and studies under way at the Forest Products Marketing Laboratory in Princeton, W. Va., and at other Forest Service units in efforts to develop new information that can be used to make wood products more competitive with other materials. Emphasis on Appalachian hardwoods.

*Longwood, Frank R.
1964. **The objectives and program of the U. S. Forest Service's Forest Products Marketing Laboratory.** South. Lumberman 209 (2609): 102-105.
Discusses the need and justification for research in wood-products marketing. The Forest Products Marketing Laboratory, near Princeton, W. Va., is attempting through surveys and analyses to reduce the unfavorable marketing conditions for wood products. To assist the industry further, the Laboratory will also conduct pilot tests of new products or processes.

Longwood, F. R.
1964. **West Virginia forests — and their potential.** Appalachian Power Co. Development 4 (6): 4.
Employment and economic returns could be greatly increased if logs and lumber from West Virginia Forests were processed locally into finished wood products instead of being shipped out of the State for manufacture into consumer goods. Outlines opportunities for potential new industries and wood uses in West Virginia.

Sampson, George R., and William M. Crosswhite.
1964. **Marketing forest products in Delaware.** Univ. Del. Agr. Expt. Sta. Bul. 351, 22 pp., illus.
A cooperative survey of 20 timber buyers and 50 owners of farm woodland in Delaware indicated that there are adequate supplies of raw forest products in the State. Most buyers of forest products have small operations. Woodland owners selling on a log-scale basis were found to be better satisfied than those selling in other ways.

Utilization Improvement

Jorgensen, Richard N.
1964. **Seasoning techniques for beech.**
Keystone Kiln Drying Assoc. mimeo. 7 pp.
The problems, conditions, and solutions for the complete seasoning of beech lumber from the sawmill through the dry kiln.

Jorgensen, R. N.
1964. **The Forest Service, USDA, utilization improvement project.** *In* Wood for people. Univ. Mass. Col. Agr. Coop. Ext. Serv. Pub. 414: 51-54.
Describes the utilization-improvement project as generally carried out through the 10 Forest Service Experiment stations, with particular emphasis on the activities in the Northeast.

Jorgensen, Richard N.
1964. **The pros and cons of saw types used in pulp chip production.**
Forest Prod. Jour. 14: 152-154, illus.
Reviews methods in use, or under consideration, for producing salable pulp chips as a byproduct of the lumber manufacturing processes. However, most of the sawdust resulting from the production of sawed products still goes unused.

*Jorgensen, Richard N., and Sophie L. Lecznar.
1964. **Anatomy of hemlock ring shake associated with sapsucker injury.**
U. S. Forest Serv. Res. Paper NE-21. 9 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Microscopic study of wood from hemlock trees having ring shake attributed to feeding attacks by the yellow-bellied sapsucker revealed the schizogenous traumatic resin canals and traumatic parenchyma characteristic of wound formation. The anatomy of the wounds is related to the feeding habits of the sapsuckers.

Simmons, Fred C.
1963. **Wheel tractor logging.**
Forest Prod. Jour. 13: 313-317, illus.
Describes the developments in design and construction that have made the wheel tractor spectacularly successful in logging work on a variety of rough terrain conditions. Relates increasing use of wheel tractors to lower logging costs.

Ostrander, Myron D., Robert A. Campbell, Erwin H. Bulgrin.
1964. **A guide to log diagraming for eastern softwoods.**
U. S. Forest Serv. Northeast. Forest Expt. Sta., Upper Darby, Pa. 33 pp., illus.
A handbook developed primarily as a teaching aid and field reference for diagraming eastern softwood logs and trees, particularly in connection with log- and tree-grade development studies. Intended as a step in standardizing procedures, diagrams, and records, the guide contains standard definitions of terms and describes procedures in detail.